MACKENZIE VALLEY PIPELINE INQUIRY

IN THE MATTER OF AN APPLICATION BY CANADIAN ARCTIC GAS PIPELINE LIMITED FOR A RIGHT-OF-WAY THAT MIGHT BE GRANTED ACROSS CROWN LANDS WITHIN THE YUKON TERRITORY AND THE NORTHWEST TERRITORIES FOR THE PURPOSE OF THE PROPOSED MACKENZIE VALLEY PIPELINE

and

IN THE MATTER OF THE SOCIAL, ENVIRONMENTAL AND ECONOMIC IMPACT REGIONALLY OF THE CONSTRUCTION, OPERATION AND SUBSEQUENT ABANDONMENT OF THE ABOVE PROPOSED PIPELINE.

(Before the Honourable Mr. Justice Berger, Commissioner)

Yellowknife, N.W.T.

March 14, 1975.

PROCEEDINGS AT INQUIRY

VOLUME XVIII

ALLWEST REPORTING LTD.,
4299 CANADA WAY,

APPEARANCES:

Mr. Ian G. Scott, Q.C. Mr. Stephen T. Goudge, Mr. Alick Ryder and Mr. Ian Roland	for Mackenzie Valley Pipeline Enquiry;
Mr. Pierre Genest, Q.C. Mr. Jack Marshall, Mr. Darryl Carter, and Mr. John Steeves	for Canadian Arctic Gas Pipeline Limited;
Mr. Reginald Gibbs Q.C. Mr. Alan Hollingworth	for Foothills Pipelines Ltd.;
Mr. Russell Anthony, Prof. Alastair Lucas & Dr. Andrew Thompson	for Canadian Arctic Resources Committee;
Mr. Glen W. Bell and Mr. Gerry Sutton	for Northwest Territories Indian Brotherhood and Metis Association of the Northwest Territories;
Mr. John U. Bayly	for Inuit Tapirisat of Canada and the Committee for Original Peoples' Entitlement;
Mr. Ron Veale and Mr. Allan Luke	for Yukon Native Brotherhood;
Mr. Carson H. Templeton	for Environment Protection Board;
Mr. David Reesor	for Northwest Territories Association of Municipalities
Mr. Murray Sigler	Northwest Territories Chamber of Commerce

I N D E X

E R R A T U M

For "CAGL" it should read "CAGSL"

Yellowknife, N.W.T.
March 14, 1975.

(PROCEEDINGS RESUMED PURSUANT TO ADJOURNMENT)

MR. SCOTT: Mr. Commissioner, I thought I should report to you that I've received another letter from the Minister of the Environment. It's a letter that foretells the events of last weekend but indicates in a general way the posture of the Department for the future, and I just thought as the other correspondence from her had been read and made part of the record, I should read this as well.

It's undated:

"Dear Mr. Scott:

I acknowledge receipt of your letter of March 5, which was dictated by telephone. My officials have communicated with you and you have now received the letter I had addressed to Commissioner Berger assuring him of my fullest co-operation. In summary, all information available to the Department of the Environment, as well as the expertise that we possess, can be used as testimony. In order to make the arrangement to utilize all information and expert knowledge we have readily agreed with your suggestion to meet with you at the earliest possible time and have delegated Dr. J.S. Tener to meet with you in Edmonton on Sunday, March 9th.

In conclusion, I am pleased to note that the Commissioner at no time doubted about

our fullest co-operation and I wish through you to thank him for his confidence. I would encourage you in closing to maintain close liaisson with our Departmental officials so that our resources will always be utilized effectively."

And it's signed by Madame Sauve, and I simply repeat what I said the other day, that if any of the participants have any difficulty in applying the arrangements that we then outlined, I would be grateful if they spoke to me at the first opportunity so that we can take a hand and see to it that Madame Sauve's wishes are fully respected.

The second matter, Mr. Commissioner, is -- relates to the request that Mr. Anthony made yesterday. It's a matter of some significance, and I would request that your ruling on this matter should be deferred for an unstated or unspecified period of time. I have communicated to Mr. Genest and to Mr. Anthony my views that this deferment should occur, and they have agreed to submit to my suggestion -- if I can put it that way -- on the understanding that the matter can be raised by either of them at any time and more particularly, if not raised before, when Messrs. Dau and Williams return on the construction panel or when Mr. Horte gives evidence, as Mr. Genest said he would.

In Mr. Genest's absence, I have communicated this to Mr. Marshall and I understand that he concurs.

THE COMMISSIONER: Excuse me, Mr. Marshall, is it intended to call Mr Horte as as a witness or as a member of any panel in Phase 1?

MR. MARSHALL: Yes sir, I propose to call him at the end of Phase 1. He will likely have supporting him a panel.

THE COMMISSIONER: Mr. Bayly?

MR. BAYLY: I believe we left off yesterday, Mr. Commissioner, with considerations regarding repairs to pipeline facilities should they break, and how they would be carried out, and whether these were one of the things that were considered in route selection.

GUY LESLIE WILLIAMS,
PHILIP HARVEY DAU,
JOHN DOUGLAS MOLLARD,
DAVID WILLIAM WATSON, resumed:

CROSS-EXAMINATION BY MR. BAYLY (CONTINUED):

Q If I might ask the panel then following that up, regarding the selection of the prime route and in particular that portion of the prime route which goes across the north slope of the Yukon, was a study done of the weather conditions during the proposed construction months, prior to choosing the prime route?

A Yes.

Q And could you give us the name of that study and give us a synopsis of its findings and how it related to your choice of this as the prime route?

A It's not a formal report in that sense. It was in our work papers. I'm sure a summary could be made available, I do not have it here.

Q All right, do you know of your own knowledge the contents of that report, and could you give us some idea of what the findings were?

A It's a summary of all of the weather information that we could find. It lists extremes in temperatures, averages, I believe it has some information with respect to snowfall, rainfall in the summer, that type of information that is available in published documents.

Q And when you say "published documents", then this was information that you've gathered rather than generated through Northern Engineering Services?

A That's correct, yes.

Q And do you know over what time span that weather information was gathered prior to your choice of this as the prime route?

A It depends on the local stations. I seem to recall that the weather information from Aklavik, for instance, goes back many years. Some of the weather information from the Dew Line Stations obviously only go back to the point in time that the Dew Line was built.

Q All right. If I were to suggest to you, Mr. Dau, that during the construction months, that north shore of the Yukon, the Beaufort

Sea side, is prone to some bad blizzards and white-out conditions which last for long periods of time, in some years. Would you be able to agree or disagree with me?

A I would agree with you.

Q And would that effect construction schedules?

A Yes, it does.

Q And has that been taken into consideration in choosing this as the prime route?

A Yes, it is part of the consideration.

Q All right, and in spite of that you felt that you could still recommend that as the prime route, is that correct?

A That is correct.

Q Now, with regard to snowfall, I understand for example, in order to do your construction on snow and ice routes, roads, you may require a large amount of snow, is that correct?

A Yes.

Q Has the snow fall been gauged in the north slope area?

A Yes, I had assumed that this type of questioning would come during the construction phase and I do not have that information with me.

Q All right, I did not want to go into the details, I just wanted to know whether or not this was something that was taken into consideration in the choice of this as the prime route.

A It was.

Q And over what period of time was it studied in your recollection?

A Well, similar to other weather information, the data that was available from --in published information from weather stations. In addition to that there were some studies that were performed -- I believe they were limited to Alaska, although I am not positive. I would have to check into that. And those were initiated by the applicant.

Were you aware that last year was a year of almost no snowfall in that north slope?

A Yes, sir. We built a test site and built a winter snow road last year during that low snow fall.

Q So you found that it was possible to do it even in that kind of condition, is that correct?

A Yes, sir.

Q And you can do it then underconditions of very heavy snowfall as well such as this year?

A Yes.

Q Now, one of the things that has been puzzling me, Mr. Dau, is just what the term "prime" and "Prime Route" means -- we have been using it so often, does it have to do with the best route in all circumstances or is it largely an engineering and economic consideration that makes this the prime route?

A I am not sure who first

used the word "prime", it is -- my understanding is that it is not just engineering and economic consideration, it is the prime route considering all considerations.

Q And do you mean as "prime" best route or first choice, or the one --

A First choice I would --

Q All right, you have stated earilier in cross-examination that other routes would be possible if they were recommended and given to you by Governments or whoever.

A Yes, that is correct.

Q Now, in route selection I am wondering if the Native peoples were consulted about the following, in the studies that you did and I have a list of things here and I will read them out ot you one at a time and perhaps you can comment on them. The first place was with regard to weather conditions.

A Not to my knowledge.

Q With regard to ice conditions?

A Yes, I am sure that they must have been, but I do not have an instance, I could not give you --

Q All right, would Mr. Williams know the answer to that question?

WITNESS WILLIAMS:

A I can think of one instance. We had on our staff for a period

of several years Frank Hanson who was raised in Aklavik and I do recall discussing with him the ice situation in the delta in particular.

Q All right, with regard to precipitation -- snow fall and rainfall.

WITNESS DAU:

A I think the same would apply as Mr. Williams has said, I am sure that that has been discussed with Frank Hanson. I know of no other specific information.

Q All right, is that true, Mr. Williams that you spoke to Mr. Hanson about rainfall and snowfall as well, or do you recall that?

WITNESS WILIIAMS:

A I am sure I did and also during the many months that I spent at the Sans Sault Test Facility we had several native employees working with us there and I do recall discussing this with them on many occasions.

THE COMMISSIONER: You said you had native employees at the Sans Sault Test site. That is somewhere between Norman Wells and Fort Good Hope, is it not?

A That is correct.

Q Were those employees employed in a -- to advise Northern Engineering or Arctic Gas about such matters as rainfall and snowfall or were they doing -- were they employed to do other tasks, sir.

A They were employed to do other tasks, sir.

Q Such as what? Working in the cafeteria, that sort of thing?

A No, sir, they were -- at one point during the construction of the Sans Sault Test site we had as many as 13 northern natives working at the site. They came from -- I am sorry, they were employees of Banister Construction who were the contractors to build the facilities, they were doing work with respect to the construction of the site itself. There were a few machine operators, mainly they were labourers. Later on in the operation and maintenance of the site we had another group of about five working at the site for a period up to a year, a year and a half, at least one of them, MIke Selemeo from Aklavik --

Q Mr. Williams, are you telling me that Arctic Gas and Northern Engineering consulted these native people employed in these tasks at Sans Sault in the establishment of a site as advisors or consultants with regard to the snowfall and rainfall likely to be encoutered along the route of the proposed pipeline?

A No, sir, I am not.

MR. BAYLY:

Q Thank you, and in other words, this was conversation that you had with them quite apart from their regular duties?

A Yes, and I am sorry,

I thought that was an answer to your question -- I may have misinterpreted it.

Q Yes, all right.

Did you document any of their answers or were these just things you stored up in your head?

A The latter, sir.

Q Can you tell us what comment they had to make?

A Yes, I can comment on a discussion with Frank Hanson in particular with respect to the ice in the Delta during spring runoff. When we were initally looking at the cross-delta route we had a concern that perhaps the ice moved out of the delta similarly to what we had seen in the main body of the Mackenzie River and in a reconnaissance trip it did not appear that this was the case and this was confirmed by Frank Hanson, of his many years in that area, that it does in fact go out very quietly in the delta -- the ice, that is.

Q Now with regard to preferred or prime route selection, did you consult with native peoples with regard to their feelings on routes?

WITNESS DAU: A I don't recall such instances.

Q Mr. Williams?

WITNESS WILLIAMS: Again it would be in passing discussions rather than seeking out this information on a mile to mile basis.

Q All right, was any consulting done, to your knowledge, by anyone other than Northern Engineering Services as an input into route selection? In other words, were there people at your April, 1973 seminar from the native groups there to discuss the selection of routes?

A People were at that meeting, that seminar, who had had meetings in various communities along the route.

Q And were any of the native organizations at that meeting represented?

A I don't think so. I'm not certain but I don't think so.

Q All right. Now when you were outlining hunting areas, which you have acknowledged in various reports and in your application, the fact that they exist, did you have consultations with the native peoples about where these were and where the best ones were and where the fragile areas were?

A I did not, sir, no.

Q Do you know of any reports

on that arising out of discussions or interviews with native peoples?

A Yes, I'm sure that they are included in the Gemini report.

Q It would be to the Gemini report that we would have to look for those, is that correct?

A And possibly others. Those are the ones that come to mind readily.

Q O.K., and with regard to traplines, would the same be true with the exception of your mapping of those registered traplines that can be found by searching?

A Yes sir.

MR. MARSHALL: Excuse me, Mr. Commissioner, I think Mr. Genest read into the record the statement contained in the responses that were filed by Arctic Gas, and pertaining to this question of the mapping of the traplines, and the answer there indicates that that's the best information that could be obtained as of that time from various sources, and it's not limited to the registered traplines only.

MR. BAYLY: Mr. Commissioner, I thank my learned friend for that response. It may not be something which is within the knowledge of his panel but it is within his own knowledge.

Q Now if I could go to this status of lands document, Mr. Williams, document 3.11, which I believe now has been tendered as an exhibit.

It's No. 75. I'm not going to go through the whole thing, Mr. Bell has gone through a large part of it, but I'd like you to turn, if you would, to page 20 of that report.

A Yes sir.

Q Now on page 20 at the middle of the page, there is a paragraph referring to some map references and if I could read that paragraph to you, perhaps you could make a comment on it. This is MP-194.8 - MP-260:

"No dispositions appear on this map sheet. It Is important to note, however, that the entire route in the Canadian portion of this sheet lies within an area reserved for the hunting and trapping activities of natives from Aklavik and Tuktoyaktuk. During the last two years only two serious trappers worked this area, plus one family resident on Herschel Island."

Do you know, Mr. Williams, the source of this material about the "two serious trappers"?

A No sir, I don't. I could possibly speculate.

Q All right, would that come from Mr. Fox, the land man?

A Yes, he wrote the report and he would know where he got that information from.

Q I wonder if you could find out for us and perhaps this information could be conveyed? I make this request through you, Mr. Commissioner, with regard to the sources of this information.

I don't know if my learned friend has any objection to that.

MR. MARSHALL: I think, Mr. Commissioner, we could provide my learned friend with a letter with that information, provide the Inquiry with it. I'll check with Mr. Fox on my return to Calgary.

MR. BAYLY: I'd be content with that at this point, Mr. Commissioner.

THE COMMISSIONER: Just off the top of your head, Mr. Williams, that's this coastal route, Alaska-Yukon border to Travaillant Lake, map 260, if that's what that does mean. The entire route in the Canadian portion of this sheet, what portion of the route from Alaska to Travaillant Lake is in that sheet, can you say offhand?

A Yes sir, approximately 65 miles in Canada. I'm sorry, from the Alaska-Yukon border east towards the delta, that map shows about 65 miles route in Canada.

MR. BAYLY: Q With regard to this map then, Mr. Williams, I take it the other maps take in the rest of the area that's discussed, or is MP-194.8 - MP-260, only one map?

WITNESS DAU: A Those are pipeline mileposts, "MP" stands for milepost and identifies the location on the route.

Q So this is a distance of 65 miles, I see; and that is on the coast adjacent to Herschel Island, is it?

A Yes.

Q Now, then, if I were to suggest to you that there are more than two serious trappers in this area, would you be able to disagree with me at this point, of your own knowledge? Either Mr. Williams or Mr. Dau.

WITNESS WILLIAMS: No, sir.

Q I take it then in prime route selection that because this report appears to have been out about the time the prime route was selected, that the hunting areas of the people of Aklavik were not taken into consideration in this route selection, would that be a fair statement? They were acknowledged but the route appears to go through the hunting area of these people, is that correct?

WITNESS DAU: A That is correct.

Q And were hunting and trapping areas of people along the entire route taken into consideration or was it assumed that you would have to infringe on some of them, in any event?

A I think we said yesterday sir, we had to infringe on them. There are so many that we can't miss them all.

Q And that is referring to the Mackenzie Valley, I take it, as opposed to alternate routes where hunting and trapping areas may not have been examined by either Northern Engineering Services or to your knowledge, Arctic Gas?

A Alternate routes, sir?

Q Yes.

A Such as the interior route?

Q Such as the interior route, or perhaps the Fairbanks route or --

A The reason I'm asking the question, the Fairbanks and Fort Yukon is referred to as corridors and there is a difference.

Q All right. Let's get the terms straight then. Is this the only corridor in which hunting and trapping was looked at, to your knowledge?

A I believe that is correct. We did not get into that amount of detail on the alternative corridors such as Fairbanks and Fort Yukon.

Q Could you tell us, please, what technical advances, if any, have been made to cause you to reconsider the cross-delta route as a possibility?

A In the technical sense, we have more detailed information with respect to channel crossings, crossing Shallow Bay and some test hole delta within the delta itself. We have much more information now that we had say two or three years ago.

Q What about below ice pipe-laying techniques, have they improved to enable you to consider this more seriously?

A No, I don't think the techniques have that great an improvement over that period of time. They quite obviously have improved but

that's not an important point.

Q So the important points were with regard to the fact that you didn't have data before that you now have, is that correct?

A Yes, both in the technical sense and also from the environmental viewpoint, we have more environmental information now than we had two or three years ago.

Q And you've stated before that all you were able to say is that there was a belief that at one time the delta was more fragile than you now consider it to be. Is that correct?

A That's my understanding, sir, yes.

Q Now, the cross-delta proposal, I assume, has been the result of some studies going back some period of time, and I wonder if you could give me some idea of how long this has been under consideration as an alternate route in the prime corridor?

A I would say under serious consideration in the fall of '73, September, October, something like that.

Q And is that why the water bottom survey was conducted by Kenting in April of 1974, as one of the studies that you wanted to do to collect more data -- and I'll refer to that document by number, Mr. Commissioner, it's No. 218 and it's referred to as a document upon which these -- this panel might intend to refer or rely.

A That was certainly part of the studies we performed, yes.

Q Have there been other studies, Mr. Dau?

A Since then?

Q Yes.

A Yes.

Q Now, correct me if I'm wrong, but I think one of the limitations of that study is that Dr. Wyder who did it said that the data were unreliable at depths of nine feet or less, is that correct?

A I believe that's correct, yes.

Q And is it not true that where the testing was done in Shallow Bay was generally speaking less than ten feet, and in most areas less than nine feet in that survey?

A I'm not sure if it's most areas, there are significant parts of the bay that are less than nine feet, yes.

Q All right, if you could just confirm what I have to say from that report, in any event have a look at the profiles that are part of that report, and I refer specifically to the following four profiles: 6, 7, 7-A and 8. Can you tell me from the profiles if my information or my interpretation of them was correct, that the areas tested at Shallow Bay were less than ten feet by and large, and most of the crossing area appeared to be less than

nine feet?

A That's what the profile shows, sir.

Q And can you give us an idea of what has been done since in order to get more reliable soundings at Shallow Bay?

A Yes, we considered this report very preliminary. It was conducted in a relatively short period of time. We believed that this was the fastest way of getting this information. It formed part of the preliminary investigation which resulted in improving the location of some of the originally selected crossings. In the past summer we have conducted further programs from a boat, which is much more accurate, with echo sounders, on the crossings that had been selected and the -- I believe the next panel is discussing some of this in detail with cross-sections that are much more accurate than anything that's shown here.

Q I wonder if you could help us, in letting us know whether any of these studies have been listed in the lists of documents to your knowledge?

A I would suspect sir, they are on the next panel, but I do not know for sure.

Q I wonder, perhaps, Mr. Commissioner if Mr. Marshall could help us in that area.

MR. MARSHALL: I think that next panel will deal with geotechnical subjects and in view of the decision to defer consideration -- detailed consideration of cross-delta to a later date, the geotechnical panel is not prepared at this time to go into great detail on the cross-delta. We will certainly be presenting that later. I think that we have advised the cousel for the various participants, but we have not yet furnished them with lists of various reports pertaining to specifically cross-delta. These are being assembled and we hope to have these out to you this coming week.

MR. BAYLY: I am assuming, Mr. Commissioner, that they have been prepared, because Mr. Dau's answer suggests that there were other studies and if they are coming next week I will be satisfied with that.

Q Mr. Dau, to your knowledge, were the traditional pursuits of the INdians and the Eskimos considered in choosing the cross-Delta as an alternate route?

A Yes, I believe -- I believe that in the environmental section there was some consideration of fishing and hunting. Now, the specific details I am not sure of.

Q All right, when you say hunting, what hunting would you be referring to?

A Whales.

Q And I take it then that that will be produced as part of the cross-delta material?

MR. MARSHALL: Yes.

MR. BAYLY:

Q Can you give us an idea,from an engineering point of view,what studies have yet to be done before the cross-delta route could be formally considered and proposed, Mr. Dau.

A We have concluded the technical studies in my view. That is the studies that are necessary to make that decision.

Q All right, and if I understand correctly the mechanics of the way that these things work as between Northern Engineering Services and Arctic Gas, you present Arctic Gas with an opinion that it can be done and Arctic Gas then decides whether it should be proposed, is that correct?

A Yes, the decision on whether it is to be filed or not is not ours.

Q Yes.

But you concluded then from your studies that it is a possible thing to do from

an engineering point of view?

A Yes.

THE COMMISSIONER: From your point of view is the cross-delta route, the preferred route?

A From a technical sense, yes, sir.

Q From an engineering sense?

A Yes, sir.

MR. BAYLY:

Q And that would be preferred over what has formally been proposed as the "Prime Route" in your view?

A Yes, sir.

MR. MARSHALL: Just so that the record is clear on that point, sir, Mr. Dau is stating his engineering opinion.

MR. BAYLY: I quite understand that, Mr. Commissioner.

THE COMMISSIONER: Yes, he does not purport to speak for Arctic Gas.

MR. MARSHALL: NOr does he purport to speak for the socio-economic consultants or the environmentalists.

MR. BAYLY: I gather that he speaks for Northern Engineering Services.

MR. SCOTT: I do not want to intervene at this stage, but it might be useful to -- maybe Mr. Bayly is going to pursue it --

to find out what the prime route is now. Has the prime route changed or has it not changed.

MR. BAYLY: I would be quite happy to have the witness answer Mr. Scott's question if he would.

MR. MARSHALL: With your leave, Mr. Commisioner, this is a matter that Mr. Genest dealt with the other day in his remarks. He said that the prime route has not changed from what had originally been filed.

THE COMMISSIONER: But it may --

MR. MARSHALL: But it may-- the exception of course being in the Fort Simpson revision which has been filed as an amendment to the prime route.

MR. BAYLY:

Q Would it be fair to say then, Mr. Dau, that the prime route is out of your hands -- you may have a preferred route but the prime route is the one that is proposed to the Minister?

A The prime route that you find in the application is the one that is proposed to the Minister, yes.

Q Yes, so any of your personal preferences may not necessarily reflect prime route selection by Arctic Gas?

A I do not quite under stand that.

Q You stated, Mr. Dau, that you thought that the cross-delta route in your own personal opinion was preferred over the route down the east side of the Richardson Mountains, is that not correct?

A From an engineering point of view?

Q Yes.

A Yes.

Q All right, so your preference does not necessarily mean that it becomes prime?

A I presume that follows.

Q All right, it is just that I am trying to chase down the meaning of the word "prime".

Mr. Dau, or Mr. Williams, in route selection, what attention was paid to special places of local and especially native people such as burial sites and archaeological sites and traditional camping places and traditional camping places and traditional fishing spots and this sort of thing?

A We are not aware of any conflict with such sites at the present moment. We would obviously do everything we could to avoid them. I am not aware of any at the present moment on the route selection that we have prepared.

Q All right, if I were to suggest to you that you have a compressor station on what is popularly known as Big Eddy ,would you be

able to agree or disagree from your knowledge of what is called the prime route?

A I do not know where that is, sir.

Q On the Husky Channel. Mr. Watson gives the appearance of having some knowledge on that question, perhaps he could assist us.

WITNESS WATSON:

A You are referring to the location of the compressor station in that area?

Q Yes.

A There is a compressor station in the area that you mentioned immediately west of Husky Channel on the west side of the delta.

Q And is that near what is popularly known as Big Eddy?

A I am not familiar with what is popularly known as Big Eddy.

Q All right, if I were to suggest to you then that it is, you would not be able to comment one way or the other? And if I were to suggest to you that Big Eddy is a very important fishing spot to certain peoples in the delta you would not be able to comment on that then, I take it?

A Not personally, perhaps our environmental consultants would be able to comment on that when their panel comes up.

Q All right.

Do you know, either Mr. Dau or Mr. Watson, of any inventories of such sites, either

the archaeological and burial type of sites or traditional camping, hunting and fishing spots that has been conducted by any of your consultants or any consultants known to you for Arctic Gas?

WITNESS DAU:

A NOrthern Engineering did not retain such consultants, but it is my understanding that there was an archaeologist at the April seminar, that I believe had been retained by Arctic Gas

Q Did he plot these archaeological sites for you?

A I am not sure. Perhaps Mr. Williams --

WITNESS WILLIAMS:

A I am sorry -- I have forgotten the name of the archaeologist that was at the meeting, but he did present, as I recall an hour -- a half -- or three-quarters of an hour talk on archeaology aspects of the route and did point out, I think, a couple of possibilities that occurred near to the route but not on the route. -- and I am really not certain if those studies are going on now or not. Someone from Arctic Gas would have to answer that.

Q To your knowledge was the route changed to accomodate any sites with which it conflicted? Perhaps Mr. Watson can answer that as I see that he is getting ready to --

WITNESS WATSON: A I recall a discussion of a borrow site at a creek bed, it seems to me it was

north of Fort Good Hope, not too far, where we had suggested a borrow site and I think the archaeologist, I wish I could remember his name, suggested that that not be done.

Q Perhaps you wish to consult that volume that Mr. Dau was showing you.

A His name is -- Miller. M.I.L.L.A.R., J.F.V., initials.

Q This was the archaeologist that you are referring to?

A Yes.

MR. MARSHALL: We would propose to call evidence as part of the environmental phase of the hearings pertaining to archaeological matters and I would refer my friend to the archaeological supplement that has been published as part of the biological report series where you will find Dr. Millar's report.

MR. BAYLY: Yes, Mr. Commissioner I am aware of that report, I just wanted to know if it was considered in prime route selection.

Q Now, you were cross-examined as a panel on the question of looping the line and I am wondering whether a schedule has been proposed for looping.

WITNESS DAU:
A No, sir .

Q And you have already stated that in your opinion the additional lines required for looping could be accomodated in the 120' right-of-way plus 20 feet, is that correct?

A I believe I said approximately, there would be areas where that may vary. We have not done a study to determine precisely what is required. It is not a large area that is required.

Q Have any studies been done which would suggest one way or the other, whether two pipelines that close together would be too close to be safe and would be too close in light of the kinds of soils they were going through?

A No.

Q No studies of that sort?

WITNESS DAU: Not by us, not by Northern.

Q And with regard to what you've referred to as Gibson Gap or Gibson Pass, would it be possible to loop the line and run two lines through that very narrow pass and still have them an appropriate distance apart?

A Yes sir.

Q All right, now I've used that word "appropriate", I suppose I borrowed it from you. What is an appropriate distance apart?

A Again, we've not performed any studies to determine what that should be. Off the top of my head, something on the order of 20 or 30 feet, I think, would be appropriate, but it would obviously require study.

Q Yes.

A There are many pipelines that have been looped with closer spacing than that.

Q Now, you have biologists on your staff, Mr. Dau, is that correct, plant biologists?

A Botonists, yes.

Q Now, if I were to suggest to you that if looping occurred fairly early on, that the recovery rates of the pioneer grass species that would have started on the pipeline route, that their recovery rate is much slower if they are intruded upon before they have a chance to get properly established?

A That sounds reasonable, sir, but you'd have to discuss it with them.

Q Have any studies been done on that aspect from the point of view of looping this line on the prime route?

A Not to my knowledge, I'm pretty sure they haven't, sir.

Q So these again would be among the studies that have to be done in order to consider looping at all?

A Yes, I'm sure that's correct.

Q Mr. Watson, you have referred in cross-examination to alignment sheets regarding the routing of the proposed highway and its relation to the proposed prime route, and you said that you had some that were perhaps not entirely up to date, and I'm wondering -- but that they were moderately up to date -- and I'm wondering if these are documents that you have in your possession?

WITNESS WATSON: Yes, I do.

Q And I'm wondering, Mr. Commissioner, if Mr. Marshall can either tell me that these have already been listed as documents, or can produce those for us?

A These are a set of working alignment sheets that I have with me. They are the same sheets that are filed. I just made a few changes where there have been variations from the highway route between the filing and the

present date.

Q You have up-dated then the alignment drawings that are submitted as Exhibit 67 and following?

A No, I haven't. All I have done is pencilled that line on a set of drawings of my own. We have not up-dated the originals.

MR. BAYLY: All right, I'm wondering, Mr. Commissioner, if we could have the benefit of those perhaps put in as an exhibit?

MR. MARSHALL: Mr. Commissioner, it seems to me that there is no difficulty at all in making Mr. Watson's alignment sheets with his pencilled notes containing information obtained from the D.P.W. available for inspection. I see no point really in putting them in as a separate exhibit. If Mr. Bayly would like to have them examined, we could make arrangements for that right now if you like, you could examine these, or if you want to do it at a later date, the witness has indicated that he has got some information from the D.P.W., more recent than that Arctic Gas had at the time the application was filed, but they're not completely up to date, and it might be rather misleading to put the matter into evidence.

MR. BAYLY: Well, Mr. Commissioner, I can satisfy myself by looking at the document. The question is whether you will be satisfied if I look at the document, and --

MR. ANTHONY: Mr. Commissioner, I'm sorry, I raised the issue in cross-examination, and

it was my understanding at that time that that information would be made available to the Inquiry, and I am trying to find it in the transcript and am unable at the moment, but it certainly was my understanding.

MR. BAYLY: I'm quite prepared to leave this point while the transcript is being examined and come back to it at the end of my cross-examination, Mr. Commissioner.

Q Now, Mr. Dau, if I could go to your criteria for route selection on page 7 of your summary of evidence, and looking at point 1,

"The proximity of the pipeline to other known and probable future sources of supply,"

now I take it that some of the known sources of supply are the five clusters of wells that Mr. Ballem and his clients are interested in.

A Yes.

Q Would you tell us from your knowledge and with regard to the selection of this as the prime route, what other known sources of supply are in the area of the prime route, and what other probable and future sources of supply are contemplated in the prime route, and I don't expect you to give me exact map references, but I'd like to know what sort of a field you're looking at in your prime route selection.

A Can I have one moment to find a map?

Q Certainly.

A Sir, one of the alternative

drawings that lists or has a map that shows potential supply areas-- I can't find it right now -- Section 14-E, Mr. Marshall.

Q Reference could be given so that the Commissioner could be looking at the same map that you're looking at.

A This document is entitled

"Alternative corridor drawings,"

sub-section 14.e.1.10. I believe it's Exhibit 60.

Q Looking at a specific map, Mr. Dau?

A It's about the third page in, drawing number is 4-0204-1014, revision 2.

Q May I read that back to you because I don't know if I've got it. 4-2004-1014 division 2.

A I think that second series of numbers are reversed. 0204.

Q 0204, thank you. Mr. Commissioner, have you got that? Could you tell us then, Mr. Dau, what --

A Yes, this map shows the geo -- provinces and basins and I'm referring specifically to the north slope, is an Arctic slope basin and extends from Prudhoe eastward across the north slope of Alaska and Canada. Obviously it's my understanding that has a potential, it shows the location of the Mackenzie Delta, Beaufort Basin, and continuing down the Anderson Plain all the way down the line. I won't go into all of them, but there are --

Q Could I stop just for a minute?

A Certainly.

Q When you say "all the way down the line" do you mean all the way down the proposed pipeline route?

A Yes, to the 60th Parallel.

Q So the sedimentary basin then continues right the way up river, is that correct?

A That's correct. It also indicates that there are areas, for instance, in the interior and the Yukon, that are not -- have no potential and are not sedimentary basins. There are some, of course, in the Yukon that are, that have sedimentary basins, that have some potential. Now I'm not qualified to rank them. I understand, I suppose there will be other witnesses who could do that.

Q So it is possible then that, because there is a possibility of finding gas all the way up the river, that the -- a very important reason for selecting this as the prime route, is that the pipeline travels up the same river.

A I think it would be more to the point along the Arctic coast, sir. On this map it clearly indicates that the interior route passes through a rather extensive area that has no potential, where the coastal route passes by an area that apparently has a potential.

Q And is one of the other reasons because of the possibility of piping gas from

eastern ARctic fields to this line as well?

A By "eastern Arctic" you're referring to islands?

Q Yes.

A No, I wouldn't think so, sir.

Q So this prime route then would be,in your estimation, preferable not only for other factors, but for the fact that there is,on the north slope of the Yukon,a high possibility of finding future gas supplies there, and as well down the -- or up the Anderson River and up the Mackenzie?

A Yes sir.

MR. BAYLY: Mr. Commissioner, with the exception of the question that I had asked regarding the -- Mr. Watson's knowledge of the highway route changes, which I understand from Mr. Marshall may not be entirely up to date, I've finished my cross-examination. I would like to be able to find in the transcript just what Mr. Genest did say about these but I don't want to delay this morning's proceedings, and perhaps if I could be allowed to reserve my right to ask that question after Mr. Scott has completed his cross-examination, with one exception, I with one exception have concluded. I have one set of questions and that is going back to 3.11 and just following up Mr. Williams, your answers to Mr. Bell. I take it -- and I'm referring to page 21 of that report -- that not only were the people Mr. Bell referred to,not consulted about the routing of the pipeline over their

traplines, but that neither were the following people: Ida Joe, David Husky, Danny Gordon, Eddie McLeod, and John Lenny, as well as the 50 trappers in the group trapping area in Old Crow.

Would that be fair to say?

WITNESS WILLIAMS: I can certainly say that no one from Northern Engineering contacted these people with respect to the route location. I think I did say earlier that I was sure that other people had.

MR. BAYLY:
All right, that was what I meant by your company. I have no further questions at this time, Mr. Commissioner.

CROSS-EXAMINATION BY MR. SCOTT:

Q Mr. Dau, I had occasion earlier to pass a comment about the weather to one of the members of the panel. I presume that when you give evidence before the Federal Power Commission you won't list me as a consultant without the appropriate remuneration. I'd like to begin by asking some general questions which may lead you to say, "Where has he been for the last two or three days?" But which are designed so that I at least will understand the process.

Now in the first place th is going to be Arctic Gas' pipeline, is that correct?

A That's my understanding, sir, yes.

Q And that your function is

consultants to them, and that means that your obligation is to make recommendations to them and in this context recommendations with respect to route.

A Yes.

Q And whether they act on those recommendations or not is for them to decide.

A Yes.

Q Well now, after they have made a determination with respect to your recommendations, I take it that applications are made to the Minister for an easement and to the National Energy Board for a certificate of necessity, or whatever it's called.

A Yes.

Q And at that stage you really have done three things: You have done a preliminary route selection; you have had input from various consultants to determine the adequacy or the propriety of that route; and you have selected a prime route.

A Yes.

Q And the application to the Minister or to the Energy Board at this stage is fundamentally based on the alignment sheets that are an exhibit here.

A Yes.

Q And those alignment sheets only locate the route with respect to the scale that is used on the sheets themselves.

A I think I know what

you mean, yes. You're saying that we can't precisely go out in the field and say, "Within a foot this is where we are."

Q Yes, it's even a little more than that.

A Yes.

Q You can't say within 50 feet.

A That is correct.

Q And therefore what confronts the National Energy Board at this stage is a prime route selected by the applicant, after your advice, which in a general way discloses the route that will be followed by reference to the alignment sheets.

A I would think in a general way it's too broad, at least in my definition of in a general way.

Q All right. Well now let us assume that the certificate is granted by the Energy Board.

A Yes sir.

Q I take it that at that stage you are already moving toward final design.

A Moving towards it, yes.

Q In the sense that you are doing the terrain analysis, the engineering work, the design work that is necessary to produce a final workable design.

A Yes.

Q And that is a continuing process.

A Yes.

Q And I take it that as you approach final design, one of the things you do is you survey.

A Yes.

Q And the survey enables you to precisely or much more precisely locate the line with reference to the alignment sheets.

A That is correct. It's my understanding that the National Energy Board, for instance, requires a plan,profile and book of reference. This plan, profile and book of reference is developed from an engineering survey that locates the right-of-way in relation to other legal boundaries. It defines the extent of lands that are required, and it lists the ownership of the lands. This document has to be approved before you get leave to construct.

Q Yes, I was coming to that.

A I'm sorry.

Q Substantially all that work in which the line is designed and the line is placed with precision on the drawings is done traditionally after the certificate of necessity is granted.

A Yes.

Q And then when you have done that, you go back to the Energy Board with an application that precisely details the location of the line and ask for permission.

A Yes.

Q And I take it that when you go back as a matter of practice to the Energy Board, you will have made many alterations in the locating of the line.

A From that shown on the --

Q Alignment sheets.

A -- originally filed alignment sheets, yes.

Q And those alterations will be dictated by a variety of factors, such as economics, the actual terrain you find when you go on the ground, design problems or features.

A Yes.

Q So that we must recognize, must we not, that the alignment sheets are only a general guide to the location that may ultimately be developed.

A Again, with the definition of "general", it's the best we can do at this stage.

Q All right. Well let us assume, I think what you're saying is, it's the best you can do without spending a whole lot of money and going over the route foot by foot, as you will ultimately have to do.

A That's correct.

Q Well now, let us assume the Energy Board gives permission to construct. I take it that even after that, there will be in the normal

course, revisions of a more minor type which will be dictated by particular design problems, or particular terrain problems, as you confront them in the course of construction.

A As a normal course of events, yes sir.

Q And that at that stage, you make what is called, I think, a request for revision approval of the National Energv Board.

A Yes.

Q And they grant, I take it, at that stage it's almost a matter of course, one hopes, I suppose, they grant a revision approval.

A Yes sir.

Q Well now, let me just ask you one or two other questions. Are you able to tell us what your timetable is with respect to final engineering design and with respect to the survey work that will be necessary for the second National Energy Board application?

A The permit -- and I'm just picking dates for illustrations -- if we obtained the necessary regulatory approval on January 1, 1976, --

Q And you're talking about the certificate of necessity?

A Yes, from the National Energy Board and the financing is complete and we're ready to go.

Q Yes.

A Prior to that date we hopefully would have some confidence that we were going to get such approval , and we would be getting ready and doing some of the more important locations such as at river crossings, which are key locations. Some of that work would have bean done at that stage. If the construction is to start on November 1 in the winter of 1977-78, we have a period of time, that's approximately 20 months, to do the type of work with respect to survey and detail location that you're talking about, that is sufficient time to be ready to allow construction starting on November 1, 1977-78, recognizing that we're not going to be working on every section of this pipeline simultaneously. In other words, it will be phased. If the construction program takes place over three winters, and two summers, obviously we don't have to have all of the survey done in the first initial phase.

Q But I take it that what that means in practical terms is that between now and the drawings on the alignment sheets, you will have to do very substantial on-the-ground terrain analysis and survey and design work to ascertain with any real precision where the pipeline will go and how it will be constructed.

A I'm not quite sure what you mean by "more extensive terrain analysis".

Q I'll give you an example, if I can. When Mr. Gibbs was talking about the Ebbutt Hills, the other day, Dr. Mollard indicated that

that wasn't the easiest part of the line and that there might be some problems there, and I take it that those problems won't be found really by flying a plane 20 miles abov e the surface of the earth; they will be found by going into the ground and doing a detailed analysis of what you find there, and applying to it whatever construction techniques you can devise.

A Yes, I understand your question.

Q And it may be, as Dr. Mollard said, that having done that work, it may be necessary to move the line five or ten miles, I think was his phrase -- it was just offhand obviously -- one way or the other if the problems are serious and if the design solutions aren't available.

A I think those numbers five or ten miles are far too great. It's not, in my view, it's not necessary -- there would not be a move of that magnitude, but I agree --

Q Say five miles?

A Beg your pardon?

Q Say five miles?

A A lateral movement, in my view, of a few miles, two, three, something like that, could solve the problem. But I agree with you that there are critical areas and that is one.

Q I take it to be fair -- I'm sorry.

A That is one. There appears to be some concern with respect to the stability

of the Ebbutt Hills. Quite obviously we would want a program, a drilling program to determine precisely what's there. It would be very similar to a critical location such as at a river crossing.

Q So that I take it when you get to that work, that work may produce a reasonably substantial location change?

A It could sir.

Q Yes, and of course we are not talking about a location change merely at the Ebbutt Hills because it will affect the line of the pipeline for some area before you get to the Ebbutt Hills and afterwards.

A That is correct.

Q Yes, a pipeline does not bend at right angles to accomodate a particular problem?

A That is correct.

Q Yes, and I take it that there are other critical areas all up and down the route, particularly at river crossings where this kind of thing will occur.

A That is correct.

Q And furthermore there are critical areas, I suggest to you that you do not even know about yet and will not until you get out there.

A That is correct.

Q Well, let me ask Dr. Mollard, if I may, one or two questions about his role. I think I understand what it was. I understand, Doctor, that -- and in answering these questions I ask you not to concern yourself with the other corridors that you examined and not to concern yourself for the moment with the Travaillant Lake and north shore parts, just think of the corridor that runs from

Richards Island down the east side of the river to the Alberta border and I take it that as you said in your evidence the other day, you were given a corridor of about ten to fifteen miles.

WITNESS MOLLARD:

A Well, that was early, yes --

Q Yes, and then you were able to reduce that down to a corridor with the aid of photographs, of four to nine miles depending on the scale of the photograph?

A Well, I examined --I think what Mr. Dau was referring to there was early in the study we did this broad regional examination and then I looked at a narrower corridor at that time going back to 1971. At that time I do not think that the route that you are referring to on the east side was in the picture.

Q Well, let me ask you this. When did you begin to look at a corridor, let us say, four to nine miles that coincides with the Richards Island/ Alberta border prime route?

A Well I examined --

Q Well, just tell me the time, Doctor, if you will -- when did you begin to do that?

A Well, I examined the whole corridor back in -- prior to '71 -- that is, as I mentioned, from sort of mountain peak to mountain peak, and at that time I looked at a corridor of this

varying width through the valley.

Q All right, and I take it that your task was, dealing just with that corridor, at the moment, your task was essentially to prepare a map for your client which showed the terrain as you had analysed it and which ultimately is the alignment sheet? Any doubt about that?

A I am just trying to think back. I think the object of that exercise was to get an assessment of the terrain along that broad band, rather than the narrow, narrow band.

Q Well, ultimately, Doctor, you produced a map which has these markings on it as shown I think on the alignment sheets, in which you describe the terrain.

A That is right.

Q Yes. Now, what I want to know is this. I take it that apart from your consultative function, your prime function was to produce those maps.

A Maps that are in the alignment --

Q Yes --

A Yes -- that is right.

Q All right, now what I want to ask you is when were you able to produce maps that dealt with the corridor from Richards Island to the Alberta border?

A Well, they came as they were sent to us by the client. The strips were sent

to us and we terrain typed them, and that --

Q Yes, but I take it that the terrain typing was done for this part of the line by 1971.

A No, I am sure that it was not.

Q Well, when was it done?

A In '72 --

Q When in '72 do you think that it was complete ?

A Well, we have been doing it on and off since '72 as the alignment sheets came in and the --

Q Well, would you agree with me that your terrain typing maps -- I am talking only about the corridor Richards Island down to ALberta --

A Yes --

Q -- was substantially done by 1972.

A No, I am sure that a lot of it was done after that. The Travaillant Lake area and --

Q I am concerned about that, Doctor, because the "canned" evidence, if I can use that expression, reveals that a route was given to the consultants at a certain period of time and I presume that a route would not have been selected without your terrain analysis map. Now, does that help you to tell me when you got into the hands of Northern Engineering the terrain analysis map that deals with

this corridor in substance?

A Well, I really cannot tell you the date because we did it over such a period of time and -- I think the major part of it was done in '72 though, that would be my recollection -- '72-'73 --

Q That is what I thought -- all right.

Now, I take it that after the maps are prepared your function is to be available to be consulted and to help answer any questions that you can.

A Yes, if I am asked.

Q Yes, if you are asked.

--And it is not your obligation to make any judgment as to the type of terrain that is best suited for the construction of the pipeline unless you happen to be asked.

A Well, as I mentioned, I discussed terrain types and the various terrain units with the people at Northern engineering on several occasions and at one point in time I had three of them --

Q I know that, Dr. Mollard --

A Yes --

Q But you are not responsible for selection of this route and responsible for the engineering characteristics --

A That is right --

Q Exactly. That is the function of somebody else.

A That is right. --

Q You provide the maps and answer questions, is that not right?

A That is right.

Q And I take it further that you do not make any judgment about the design techniques that may be required to overcome route problems on a route that in fact is selected by somebody else.

A That is right.

Q And I take it that at least at that stage you do not give any advice unless you are asked, any sort of mile by mile advice on routing of the pipeline.

A That is right.

Q You are a mapmaker.

A In this particular project, as I said, I identify, classify and map the terrain --

Q Exactly.

Well, now I put it to you that that was done at least substantially over three years ago -- the terrain typing -- for this part -- I am not talking about the new filings.

A No, I would think not.

Q Did you ever hear, Dr. Mollard, that a route had been selected without your terrain typing?

A No.

Q That would strike you as very odd -- courageous, perhaps almost foolhardy, would it not? Wouldn't it?

A Well, I would think that it would be desirable to have my terrain typing.

Q Yes, -- dangerous not to have it -- Right?

A It would depend on who selected the route and their background of experience, I would think.

Q Well, now in response to question number 17 of the Government Assessment Group which is contained in the response volume -- I do not know the Exhibit Number, sir, at page 17 -1, the third paragraph, the first sentence reads: "When the terrain typing has reached a reasonable level of reliability, it can be used with confidence to locate the pipeline within fairly narrow corridors. This level of reliability was obtained by the applicant and its consultants over three years ago."

Now, would you agree that you obtained an adequate level of reliability in respect of terrain typing over three years before this response was filed?

A Yes -- I --

Q That is what your client says -- what do you say?

A Yes, I think that that is a fair statement and --

Q So the terrain typing was done over three years ago?

A No, not all of the terrain typing on the Travaillant Lake --

Q On the corridor that we are talking about from Richards Island down to the Alberta border -- leave aside the additional filings and the alternative routes.

A Yes, I think that --

Q So this statement in the response is accurate?

Are you worried about it? If it is inaccurate, tell us.

A Well, I was going to say that in the context that I read it -- I would say that in my view I did have a good level of confidence over three years ago for the whole corridor and to answer that in more detail, last night for the first time I was comparing the documents in -- from what you are reading there and I was looking at one terrain type, for example, D-L and that was very early, I think in 1971 1971, November '71 and we had six or seven holes in D-L and I had drawn a profile of the terrain type and the materials at that time in 1971.

Then in the next, a little further back in that document, there is another one of D-L when they show 527 holes versus seven and the stratigraphy that I had after seven holes was essentially the same as what is shown on the 527 holes.

Q Doctor, I do not want to cut you off, but I also want to help you catch your plane --

A Yes, okay -- thank you --

Q Let me go on. Would you

agree with me that since three years ago when your terrain typing was substantially done, later data has not altered any of your views in a significant way?

A I would not say that it has altered my views in a significant way.

Q Well, now I would like to turn to Mr. Watson, if I may -- do you want, Mr. Commissioner to take your break or is it too early?

THE COMMISSIONER: Whatever suits you..

MR. SCOTT: It is a good time.

THE COMMISSIONER: All right, we will adjourn for ten minutes.

(PROCEEDINGS ADJOURNED FOR TEN MINUTES)

(PROCEEDINGS RESUMED PURSUANT TO ADJOURNMENT)

MR. SCOTT: Mr. Watson, I understand from your evidence that you were responsible, in the first place, for plotting information that you obtained on the maps prior to preliminary route selection.

WITNESS WATSON: I think what you're referring to in my preliminary evidence, I mentioned that I was responsible for gathering the data from various sources and getting it placed on the alignment sheets.

Q Yes, that's what I meant.

A O.K.

Q And I take it that at an early stage there would have been someone who would have taken a pencil in hand and perhaps a ruler and started to draw on the basis of the information at hand, a preliminary route.

A Yes, that's correct.

Q And I take it, though, you were no doubt responsible to Mr. Williams and others up the chain, that that was really your preliminary responsibility, subject to their judgment of your work.

A Well, this initial route was picked by a number of people. I was one of them but certainly not the only one.

Q Well, let me ask you to turn -- before we do, let's just consider again the

route that ultimately became the prime route, that is the route from Richards Island down to the Alberta border without the amendments and without the western leg. Is that all right?

A Fine.

Q Well now, I take it that anybody would recognize, confronting the problem of drawing a route, that you knew where you were going to start approximately, at Richards Island.

A Yes.

Q And you knew roughly -- at least if Mr. Gibbs and his client had their way -- of where you were going to end up, at the Alberta border somewhere.

A We knew where the end point was, yes.

Q So with respect to what ultimately became the prime route, you had a starting point and within some limits, an ending point.

A Yes.

Q And the problem is to draw a line that connects the two.

A Yes.

Q And I think as Mr. Dau has said, and subject to amendments that may have been suggested by your consultants, the object is to draw as straight a line as you can, consistent with the safety and security of the line.

A Well certainly if there were no other factors involved, a straight line would

be the most economical.

Q Just see if I understand. The first thing you look for, if possible, if there are no other factors, is a straight line.

A Yes.

Q Then you look to determine whether the straight line creates engineering or design problems that can be foretold.

A Yes.

Q And that may lead to a deviation from the straight line.

A Yes.

Q Then you look perhaps to see whether the straight line will in some way damage the security of supply.

A Yes, that's a consideration.

Q You want to cross a smaller river rather than a bigger river, if you can.

A M-hm.

Q Isn't that so?

A Yes.

Q And that would be the third consideration, and then of course in this case there were all the inputs that you have described -- or that Mr. Dau has described in some detail from your environm ental staff and the socio-economic advice , if any, that was obtained by Arctic Gas.

A M-hm.

Q Which led to other

modifications.

A Yes.

Q All right. Now let's begin, if we can -- it will be very short, I don't want to take too much time -- with alignment sheet No. 1, and I think it's not called No. 1 but it's the first, it's the one that shows the Richard Island start, it's 1-A-0200-1001. It's in Exhibit 62.

THE COMMISSIONER: What's the number again?

MR. SCOTT: It's the first map, sir, I think, in the book. The number is 1-A-0200-1001.

A We have that.

Q Thank you. Well, I take it you've told us, you began and insofar as possible with the straight line principle.

A Yes, that's correct.

Q And ideally, all you would need is a ruler and a pencil and you could draw one right down to Alberta, ideally.

A Ideally, yes.

Q And you cleave to that ideal as closely as you can, bearing in mind the other considerations that are set out in Mr. Dau's evidence.

A Yes.

Q And the starting point is shown as HP about half-way along that alignment sheet, isn't it?

A HP refers to a heli-pad.

The little square there is the actual location --

Q I see, all right. The square is the starting point.

A That's correct.

Q Well now, the first thing that I see is a kink in the line. It seems to me if I had taken a ruler that I would have drawn from that square right over to the little point below the lake and then I would have had the most economical line because it would be a straight line.

A Yes, I guess that's --

Q Isn't that so, that that would have obviously been a straight line.

A That would have been a straight line, yes.

Q Well now, are you able to guess -- you may not have the details, but are you able to guess why you didn't do that in this case?

A As you mentioned, I don't have the details of this particular section. I would guess that probably the reason that line isn't straight is because of the water crossings and between, and that it was meant to facilitate a more desirable crossing.

Q So what I'm suggesting to you is that in drawing that line, you didn't really begin from the square at all, you went first to the water crossing and said, "We're going to have to cross that river, where is the best place to cross it?"

A Well, when we got down to this level of alignment, I think that they started

at the starting point and there are key points along the line which we attempt to get in as straight a line as possible, and certainly one of them is river crossings, others are lakes and mountain ranges, areas of potential buoyancy and so on.

Q Well, Mr. Watson, just let me ask you, if I'm right about this, and leave aside the environmental consultants and the socio-economists for the moment and let's just look at this as engineers, but that would not be accurate. You look at it as an engineer, seeking the most economical and secure route, and I take it that when you began to plan this line you made certain decisions. First of all you wanted to cleave as closely to the straight line as you could.

A That's correct.

Q The second thing, as a general matter, you would have decided fairly early, is that you wanted, generally speaking, to come down the east side of the river.

A Yes.

Q The third thing you would have decided, generally speaking, is that you didn't want to go through any lakes and you didn't want to go over any high mountains.

A That's correct.

Q And in fact you were pretty successful at avoiding lakes, all things considered, weren't you?

A Yes.

Q And I take it that after

that, you saw very quickly that the critical factor in planning your route was going to be the necessity to cross rivers and valleys.

A They are certainly a critical item on the route, yes.

Q I put it to you that having assumed the other things, you want to come down the east side, that you want to go a straight line, that you want to avoid lakes and mountains, wouldn't it be fair to say that they become the most critical factor that lead-- that may lead to a variation of the straight line?

A I think that's a fair assumption.

Q Yes, and I therefore suggest to you that looking back on it and leaving out the consultants and the socio-economists for a moment, your exercise was really to try, from the maps and the other information you had, to select at each location, the best river crossing or valley crossing that you could.

A Bearing in mind the other things that we've talked about, including the straight line.

Q Yes, and that then when you had selected the best river crossing or valley crossing at each location, I don't want to over-simplify it, but wouldn't it in engineering term become a question of joining the dots?

A Well, you would look at

that and try to deviate from a straight line as little as possible, yes.

Q Yes, but having selected the crossings that are in as close to a straight line as you can, and as good as you can get them, then you simply join up the lines. Wouldn't that be fair, as a general principle?

A You look at a straight line between these points and select the best route between them.

Q Yes, and I take it that having done that, you were forced, from time to time, to go over all kinds of terrain that Dr. Mollard had typed for you.

A We probably crossed most of the terrain types, if not all that he has classified, yes.

Q I suggest to you that with the exception of the highest mountains, you probably crossed every little designation that he set out on his terrain type, that's very likely, isn't it?

A It's quite probable, yes.

Q And I take it therefore that when you have selected the river crossings and the valley crossings and drawn as straight a line as you can, with those considerations in mind, you're really saying that, "Our engineers are confident that," -- and perhaps there is every reason why they should be, we haven't come to them yet -- "Our engineers are

confident that the terrain difficulties that may be encountered on this straight line approach can be resolved by design."

A I would say that they can be resolved either by design or re-location, if you happen to find something that definitely would indicate that re-location is the best approach.

Q But in confronting the problem of building a pipeline and drawing the preliminary lines, there were really two ways to avoid problems: One is routing, and one is design; isn't that correct?

A Well, they're used in combination.

Q Right, but I put it to you that an examination of these maps and the fact that they cross a great variety of terrain illustrates that the design solution is the solution that is going to be called for.

A I'm not sure I understand that.

Q Well, you would agree with me, wouldn't you, that when the work was done, all things considered, your prime route turned out to be pretty straight.

A Yes.

Q And notwithstanding its straightness, it crosses all kinds of terrain, from hills and valleys to bogs and rivers and even small lakes and so on.

A It crosses most terrains, yes.

Q And that really you intend to meet those problems by engineering and design.

A Yes.

Q And wouldn't it be fair to say then that the route was selected -- excuse me, let me begin again -- leave aside the input from your environmentalists, wouldn't it be fair to say that the route was selected on a straight line method, it being understood that design would be able to take care of most, if not all of the terrain features

that were encountered.

A No. The line, as you pointed out at the start, isn't a straight line.

Q No, but it's -- I put it to you that where it is not a straight line, it is not a straight line because of the river crossings, primarily, or valley crossings.

A That is one of the reasons for deviating from a straight line. There are others.

Q All right, let me put this to you. Having selected the river and valley crossings, having joined up the lines, having crossed all kinds of terrain, I put it to you that at that point you have as straight a line as you can get.

A Yes.

Q And that thereafter any solutions are going to be primarily design solutions.

A Well, I would think that that is probably true, unless it is determined that it is better to re-locate than to design for it, end detail design. This is a phase of detailed design that we will be getting into.

Q All right, let me leave that and ask Mr. Dau something. Mr. Dau, in the beginning you told us that -- and I think I have it correctly --- that it was your function to make recommendations on routing to Arctic Gas, but it was their decision.

WITNESS DAU: Yes.

Q Yes, and I take it that the recommendations you made to them were the best engineering and professional recommendations that you could make.

A Yes.

Q That question wasn't hard to answer.

A That was easy to answer.

Q Did Arctic Gas act on all your recommendations as to routing?

A I think I tried to discuss that point yesterday or the day before, in that at the time of the merger there were two routes that had been selected at that stage this panel represented Williams Brothers Canada Limited for the Northwest project. There was another group that represented Gas Arctic Systems, who had selected a slightly different route. I think I tried to explain that in some instances Northern Engineering did not go back and re-do --

Q Yes, I understand.

A -- the work that had previously been done. We examined the route that had been selected and concurred in its location. In that sense we did not do -- we initially did not select all of the route that you're talking about.

Q Let me see if I understand that precisely. At a certain stage, Williams Brothers had been responsible for route selection, and you did not re-do their work; you simply reviewed it

and concurred in the route that they selected.

A And I'm quite sure, and I can't point to this specific instance, we came up with some recommendations for minor changes.

Q All right, but in any event you made a recommendation to Arctic Gas to the new consortium, to accept that route.

A Yes sir.

Q All right. Now what I'm asking you is, in the barrel of routing recommendations you made to your client, have you ever been turned down on a routing recommendation? Now if you aren't able to answer that precisely, maybe Mr. Marshall can because I want to know what the recommendation was that was turned down.

A I can't specifically give you an example that we said, "You should locate it here," and they said, "No, we want it here." I'm not aware of any of that type of a rejection of a recommendation.

Q I take it that you would have records of the recommendations you made on routing.

A They exist as working paper documents in working copies of alignment sheets. If I could back up, sir, this also has to be in the context of delivery locations. For instance, if the delivery location in Alberta, at one particular time was -- I can recall one that was at a location called Gold Creek, and at that particular instance we had a route that was west of Camsell Bend. That resulted in

recommendation of a certain line,as delivery location changed we kept, you know, we had to move the section of line.

Q Yes, but in that case you would make a recommendation to your client as to the new location of the line to take account of the new delivery station.

A That is correct, yes.

Q Now what I'm asking, your counsel I suppose, is for a list and details of any recommendations with respect to routing made by your company which were modified or refused by your client. I understand that you mightn't have that here. Well now, Mr. Dau, your evidence, in its written form and your evidence before the tribunal indicates that I think in 1972,perhaps a little earlier,you hired a number of environmental consultants, to give you advice.

A Yes, I'm not just positive of that date, I think some were working for us prior to that time, but yes, essentially.

Q If any socio-economic consultants were advising they weren't hired by you.

A That is correct.

Q Well now, your evidence also indicates that when they were hired, they were given a copy of the route that was proposed.

A Yes.

Q And they were asked to do work, I presume, to determine the environmental impact of that particular route.

A Their first assignment was to gather data.

Q Yes.

A Obviously.

Q All right. Now have you a copy of the route that you gave them? Or can your counsel in due course provide that? I don't need it today but I would like to see the route that was given to the consultants when they were asked to gather data.

A I'm not sure. That's again a lot of work paper information; if we have it, obviously, yes, but --

MR. MARSHALL: Perhaps I can be of some assistance, Mr. Scott. The various consultants, take for example the environmental consultants, working in different areas were retained to do work at various times, and obviously their first assignment was to concentrate on the gathering of base line data. They were provided with information as to route location as it then existed, and were continually kept up to date as revisions were being made in the routing. So they would have received copies of routing changes made from the time they first started through the evolution of the route, if you like to call it.

MR. SCOTT: Well, perhaps, Mr. Commissioner, I'm sure this is within the power of my friend, he can provide for me at least initially the routing information or drawing -- the evidence of MR. Dau says a copy of the route that was given to the

consultants when they were retained, and I will understand that they would have been given subsequent information when route changes were decided upon.

MR. MARSHALL: Which of the consultants? Do you mean all of the consultants? We're talking about a period of many years and many different consultants. If you like, Mr. Scott, I'm sure you could accompany me to Northern Engineering's offices and we could give you --

MR. SCOTT: Not a chance.

MR. MARSHALL: -- we could show you all the documentation as to changes in route in the very early days of this right through. It seems to me that you perhaps don't appreciate the volume of paper that you've been asking for.

Now if you want to get more specific about it, if for example you want information as to the route at the time the envirpnmentalists were being asked to come to the April '73 meeting, that is a fairly easy document to put together for you.

MR. SCOTT: Well --

MR. MARSHALL: I can certainly give you all the rest if you like, but it will take some time.

MR. SCOTT: -- perhaps, Mr. Commissioner, my friend and I could resolve it this way, I could prepare, it advised, a list of the consultants with which we're concerned, and ask him to let me know the route information that was provided to them; and secondly, I gratefully accept his offer

to produce the routing information that was given to the environmentalists who came to the April seminar. Perhaps that can be done without taking time of the Inquiry.

Q Well now, I take -- I'm sorry.

THE COMMISSIONER: You can provide that, can you, Mr. Marshall?

MR. MARSHALL: Sir, we certainly -- my understanding is, we certainly can provide the routing information that was given to the environmental and other consultants for purposes of the April 1973 week long meeting that dealt with route. That can be provided, I believe, next week.

With respect to the other information, I gather Mr. Scott will give me a list of specific consultants and I'll endeavor to dig up information as to the routing information given to those various consultants, the time they were first retained, and thereafter.

THE COMMISSIONER: Yes.

MR. SCOTT: Q Well now, Mr. Dau, I take it that while you obviously saw consultants before and you've seen them after, the meeting in April of 1973 was a key event in terms of environmental and socio-economic input to the route.

A Yes.

Q And I understand that there are minutes, indeed a transcript of that meeting.

A That's my understanding,

sir, yes.

SCOTT: I wonder if Mr. Marshall can produce that?

MR. MARSHALL: Mr. Scott, there is a transcript of the meeting and the follow-up meeting that was held later on, and we can make available for your nighttime reading, about six inches, I think, of material that I'm sure will fascinate you.

MR. SCOTT: I'm just going to pass it on to somebody else to read, so it won't be any problem; but I raise that, Mr. Commissioner, because it was listed on the Environment Protection Board's documents but was not intended to be released without the permission of the company, but I'm glad that --

MR. MARSHALL: Well, that's perhaps my responsibility, Mr. Scott. It seems to me that wasn't a report or a study but we don't object to producing that information to you.

MR. SCOTT: Thank you.

Q And I take it, Mr. Dau, that, as you have indicated in your evidence, that at that meeting and thereafter there were in your judgment some environmental modifications made to the route?

A Yes.

Q And I take it that on or after that date there were also some location modifications dictated by your bore hole analysis as it proceeded and the physical obstacles that you confronted in the route?

A Yes, I am sure that there were refinements after that date.

Q Yes, and I take it that it is clear that there were location modifications that were suggested by design changes and the Fort Simpson route change is perhaps the best example.

A Yes.

Q Yes, and in the fourth category there were location modifications that are suggested, if I could put it this way, by pure economics and the cross-delta proposal is perhaps the best example of that?

MR. MARSHALL: Well that may be an argument you wish to advance, Mr. Scott. We will call some evidence on that.

MR. SCOTT: Well, let me put it this way, is there anything else that dictates the cross-delta change except economics?

A Yes. I believe it is a

more secure system in the sense that it has less miles of pipe. Now, that perhaps you could relate to economics also.

Q I would not have any doubt about that, would you, Mr. Dau, that the security of supply is from the point of view of the people who are going to own it and use it, an economic question.

A Well, I agree with you, I just wanted to make sure that you understood that it was not just capital dollars --

Q Oh no, but in the context of that answer, that security of supply may be an economic question, would you agree with me that that proposal is dictated exclusively by economic considerations -- I am not downgrading it, I am simply saying -

A I understand -- I agree.

Q Yes.

Well, now I notice and I do not quite understand this that there have been some route locations down near where the highway is either going or supposed to go. There have been some route location changes of a relatively minor type compared to the cross-delta and the Fort Simpson.

A I do not understand, sir, in what time frame --

Q Well, since 1973 -- what I am trying to get at, Mr. Dau, is that in the last few years you have made two -- including the cross-delta route -- you have made two very substantial

changes, that is the cross-delta, assuming you make it,and the Fort Simpson.

A Yes.

Q And both of them we agree are dictated by either economics or design.

A Yes.

Q Yes, and indeed looked at in one way they have changed the prime route by almost half.

A You are referring to miles?

Q Yes.

A That could be, I do not --

Q Yes --

A It would be close to that I would suspect --

Q Yes, and both of those changes if they are carried forward, if they are decided on, will, I take it, lead to an amendment of your filing both with the Minister and the National Energy Board -- indeed the Fort Simpson Route change has produced an amendment to your filing.

A Yes, that is my understanding.

Q But I understand that as a matter of practice, there are route changes that have been made of a much more modest variety -- you go around a hill or something of that type --?

A I am sure that that is correct, sir --

Q Yes, yes --

A -- that is a continuing process to attempt to improve the location of the line.

Q Yes. I take it that as a matter of practice, those route changes of that minor variety which may only be several miles do not lead to an amendment to your filing ?

A I am having trouble with the "several miles". You are referring not to a lateral movement but to a relocation of several miles of route?

Q What I am getting at, Mr. Dau, is that I understand and I think there is no doubt about this, that since your filing of the alignment sheets, you have made two major changes, one of which at least has produced an amendment or proposed amendment?

A Yes.

Q You have also made a number of other changes for which -- and I am not criticizing it -- for which you have not filed amendments?

A Yes.

Q Yes.

And I take it that there will be more minor changes of that type for which it is not required in your judgment to file amendments.

A Yes.

Q How do you distinguish between a route change for which you file an amendment

and a route change for which you do not? I am curious, I mean, there is no point in this, I just want to find out why.

A In my view, sir, I would attempt to define it as a minor or major route change and in my judgment a minor route change is a change that is probably on the order of hundreds of feet in lateral movement, except for a case that I tried to explain previously, of a relocation of a highway that caused us to have to relocate the pipeline for some considerable distance because the highway relocation had removed all of the area available to us on one side of the highway. The example that I used I believe was the highway near the Mackenzie River. We were between the two, the highway moved, there was not enough room for us, we therefore had to cross the highway and that could be -- it still may be a minor change, but it could involve several miles of pipeline route.

Q It does not -- or it did not produce an amendment to your filing ?

A I would think it would not, sir.

Q Would this be a reasonably practical working definition, that you do not amend your filing if, generally speaking, the route change can be shown on the alignment sheets that you have filed, that is, if it is within the ambit of the alignment sheets?

A That seems reasonable

to me, sir.

Q Yes, but that on the other hand when a route change goes off the alignment sheets, then you have got to file them?

A I would think that you would have to file that information, yes, sir.

Q Well, now, you have been good enough to tell us about the Fort Simpson route change and I understand that that was working its way up to the surface for about a year?

A Yes, sir.

Q Yes, you told us on the other hand that the Mackenzie Delta cross route I think has been working its way a little more slowly, perhaps for about a year and a half.

A Yes, sir.

Q Yes. Have you any more at home like that?

A No, sir.

Q There are no more major route changes in the works?

A Not to my knowledge, sir.

Q All right.

WITNESS WILLIAMS:

A Mr. Scott, can I just clear up -- I think there is a mis understanding here that -- after the April 1973 meeting, when several relocations were made for environmental purposes, we took the opportunity at that time to make some other

changes that we wanted to make for geotechnical purposes and this then ended up in the route that was filed. -- And we have not put forward any changes in that route officially since that time except for the two major ones that you are speaking of.

Now, we have, in testimony, talked about the possible change at the Great Bear River and the work that is going on there, but in house we have not made any changes since the filing.

Q No, but you do not disagree, I take it, Mr. WIlliams, with Mr. Dau's general rule about the kind of change that produces the filing change and the kind of route change that does not?

A I think I would agree with what he said.

Q Yes, well now, I take it that any route change, no matter how minor, requires a certain work up period. Is that not so?

WITNESS DAU:

A Yes.

Q And that is required, so you can see whether in engineering and economic terms it is feasible?

A Yes.

Q Well, now, what I am concerned about is, are there changes that would not produce filing changes, presently in the works that will lead to deviations on the alignment sheet?

A ONly with respect to our

continuing investigations at river crossings. I think that would be the only case that I would be aware of.

Q Yes --

A If in fact we do some drilling, for instance, at Ebbutt Hills in the next few months, we might have a minor relocation there.

Q yes --

A That type of a thing --

Q I am going to ask your counsel and I am sure that he will agree to not hold us in suspense until the route -- the minor route location is final, but to let us know as these matters come -- begin to surface in your company. Is there any objection to that, Mr. Marshall?

MR. MARSHALL: No, I do not think that there is any objection to that. We will ask Northern Engineering to keep us advised as route changes -- minor route changes are developed --

MR. SCOTT:With the object that when one is being worked up, even though it may never be adopted, or even proposed, you will let at least Commission Counsel know for public purposes, that that proposal is in the works so that we will not all be taken by surprise.

MR. MARSHALL: I am not prepared to go that far, Mr. Scott.

MR. SCOTT: Why not?

MR. MARSHALL: You are suggesting that every time anyone in the organization thinks

of a possible change, works it out on a napkin at his lunch hour, that you want to be advised of that?

MR. SCOTT: No, no -- obviously a lot of that goes on. I would be content, Mr. Commissioner, if my friend were able to let me know when Northern Engineering, as an entity, begins to take seriously and begins to evaluate a scribbling that has originally appeared on a napkin. -- So that the evaluation process that the participants must be engaged in will be able to begin at about the -- roughly the same time as the evaluation process that the engineers are engaged in. That is not difficult, is it, Mr. Marshall?

MR. MARSHALL: It is a question of a judgment call, Mr. Scott. We will do our best.

MR. SCOTT: Thank you very much--

MR. MARSHALL: I agree with the principle that is something is seriously under consideration as a routing change, that the advice out to be given to the INquiry and indeed that is what we have attempted to do with more major route relocations and with respect to minor ones, we can do that and will let you know from time to time should any of these develop.

WITNESS WILLIAMS: Mr. Scott, can I clear up one further point with respect to Mr. Watson's testimony? I really wasn't satisfied with the way it was left. I don't know if he was given an opportunity to proceed farther.

Q I moved right along, Mr. Williams. Go ahead, please.

A He ended up with your analysis that picking off the key points such as river crossings and lakes and what-not, the procedure used by people selecting the line between those points is to have a stereoscope and the stereo pairs in front of him, along with the terrain typing of Dr. Mollard, and when he selects the route between these three points, he certainly does take into account the information supplied by Dr. Mollard.

Q I didn't -- so that there is no doubt, Mr. Commissioner, I didn't intend to suggest that Mr. Watson or any people on the staff would not have that before them, and indeed any drill holes that were available at that time.

A I just didn't think it had come out that way.

Q Mr. Dau, on page No. 7 of your evidence , and I refer to it there just because it's convenient, you list the factors that led to adjustments from the base economic line and I'll just read it to you because I think it's shorter:

"In the Assessment Group's report at page 161

"they list a number of other factors,"

and have you got it there?

A One moment, sir.

Page 161?

Q 161, chapter 7.

A Yes.

Q And they list there seven factors, perhaps we don't have to read them, they run from:

"Fishing, hunting, trapping and camping areas,"

down to

"critical habitat for mammals, birds and fish."

I'd ask you to read those to yourself and I ask you whether you agree that those are all factors which should be considered in the process of route selection and given due weight, whatever that may be?

A I agree,yes.

Q Did you have advisors who were able to give you advice with respect to each of the matters that is listed at page 161 of the Assessment Group's Report?

A Yes, we did, and unfortunately the advisors aren't neatly broken down into those particular sections, obviously some of our environmental advisors would cover several areas.

Q. I simply wished to ascertain that.

A Yes.

Q And certainly having heard that, that their evidence will be called.

A I think I previously mentioned, they were retained by our clients rather than by Northern itself.

Q Well now let me come to this environmental factor, and I want to deal with it. if we can, as a matter of principle and zero in on one or two examples so we can see how it works.

Now in your evidence you have said -- I can't put my finger on it right now -- that the m ajor environmental change was the determination by your company to recommend to Arctic Gas that you should go around the Travaillant Lake mammal and fish area.

A That was the major change resulting from environmental concerns.

Q Yes, and I think you've also said that that -- that your consultants were virtually unanimous in recommending that change to you.

A That's my recollection.

Q Yes. Well, I just want to see how it works. When you had this unanimous recommendation, what other factors did you take into consideration in determining whether you should act on it?

A My recollection, sir, is that that was discussed in considerable detail in the April meeting. I recall that there were -- there was a further meeting in the evening where all view-points were expressed, the route lengths were scaled,

the consideration for construction difficulties, the length of line, and that type of thing, all of those had an input into the route that is now selected. It was not done in an isolated view from an environmental view only.

Q Well, let me put it to you this way. In that case and perhaps it's the unique example, you had a substantial environmental interest in changing the route.

A Yes.

Q They were all lined up against the economists, if I can put it that way. Wouldn't that be fair?

A That's probably fair.

Q All right, and it would be apparent from the fact that that proposal was going to add to the cost of the line because you had to go out of your way.

A No question about that, sir.

Q All right, well how did you decide that question? Here you have the environmentalists unanimous and you know that if you give in it's going to cost you money. How did you decide that?

A That was the decision -- or let me back up -- the meeting I'm referring to, which was a meeting in the evening, weighed all the factors and the client, Canadian Arctic Gas, was present at that meeting, and the next day as I remember,

there was a proposal on a new route, which is the one you now see, that had again my understanding, unanimous approval of the environmentalists concerned, Northern Engineering, and CAGL staff members, at which time that recommendation by all was accepted by CAGL.

Q Well, did your firm make any recommendation to CAGL as a result of what the environmentalists told you?

A Yes, we were a party to that decision where this selected route that you now have was recommended., I believe the next morning, to CAGL.

Q But I take it that you -- or let me put it this way -- did you have any role in determining whether the costs that would be involved outweighed the environmental concerns?

A No.

Q So would it be correct to say that your recommendation then was simply based on the environmentalists' concern?

A Yes, I think that's fair.

Q In other words, it was your responsibility, if you judged it appropriate, to make a recommendation to Arctic Gas, taking into account the environmantalists' concern.

A That's correct, yes.

Q And I take it it's obvious that Arctic Gas acted on that.

A That's correct.

Q I take it it's also

obvious, is it not, that there was (as far as you know) no environmental recommendation that you made that was turned down by Arctic Gas?

A No sir.

Q So wouldn't it be correct to say in most practical terms that you were the judge of whether, as best you could, as to whether the environmentalists should have their way or not? And that your judgment would lead to a recommendation to Arctic Gas.

A I can't recall an instance where -- perhaps I could explain, which I believe I referred to the Arctic coastal plain.

Q We're coming to that, because that's another interesting example. I just wonder if we can deal with this. The point I'm trying to make to you is, you have a proposed change, the environmentalists on one side, and dollars are on the other.

A Yes.

Q That's obvious in this case.

A Yes.

Q Now when you made a recommendation to Arctic Gas, did you consider the dollar question, or did you say, "Well, that's Arctic Gas' business alone"?

A No, we had to consider the dollar question, obviously, because the first question we would have been asked is, "What is the difference in cost?"

Q All right. Well, would

it be correct to say, then, that you heard out the environmentalists and you made a judgment weighing the environmental interest against the dollar interest, and made a recommendation to Arctic Gas?

A Yes, I would have to answer that yes.

Q Well, that seems to me a very difficult thing to do. Did you have any direction from Arctic Gas, or did you prepare for yourself any scale of priorities which would enable you to make this judgment?

A We did not prepare a scale of priorities.

Q It's rather like comparing apples and oranges, isn't it?

A It sure is.

Q Well now, can you give us any help at all as to how you made that decision? I wouldn't know how to begin. How did you begin?

A Can I go back to the suggestion I was going to come up with, which is the along the Arctic coastal plain, where there are concerns about being close to the mountain or being close to the coast? Obviously that type of a discussion went on at length with the various consultants and I guess the only help I can give you is that the compromise solution by choosing what is essentially the middle ground is the only way I can respond to you. Now, in that particular instance I'm sure that the costs involved were not , you know, real large numbers; as I recall,

the differences in route lengths between the two extremes compared to the middle, you know, there's not 100% difference in route length, something like that.

Q Well, let's pass onto the north shore, because I think that's an interesting example. I'm going to ask your counsel not today but in due course to let me have a drawing of the proposed route along the north shore prior to the April 1973 meeting, and I take it the contest there was between the caribou people and the bird people.

A Yes sir.

Q And the competing interests were many and varied,were they not?

A In what sense?

Q Well, caribou is important because it feeds people.

A Yes.

Q Yes. Endangered species of small fowl are important because they may be among the only colonies of those birds that exist in the world.

A Yes.

Q Yes. How did you measure those two competing interests off against each other?

A I was going to respond by saying"with difficulty", but it is a --

Q I suggest to you, Mr. Dau, that it was impossible.

A Yes, it is a compromise. There is no way that I could put a value on a peregrine falcon -- I obviously cannot.

Q Yes, it is impossible, is it not?

A That is correct, yes.

Q You were asked to make an impossible judgment. -- And you were not even an expert in the field. I am not criticizing you, I am simply outlining the problem, is that not so?

A That is correct.

Q Yes, and you were given and had no scale of values of priorities that could be attached to any of these considerations.

A I have no such scale of

values, no, sir.

Q You were about as useful in that situation as a lawyer would be, is that not so?

A Do I have to respond to that?

(LAUGHTER)

MR. MARSHALL: I was going to suggest that Commissioner Counsel stop insulting the witness.

(LAUGHTER)

MR. SCOTT: Leaving personalities aside, Mr. Dau, that would be fair, would it not?

A That would probably be fair, sir.

Q Yes, and your client Arctic Gas was unable or did not give you any scale such as that to assist you?

A I received no such instructions.

Q Did you give any consideration to using the values that are used by various American institutions and boards to scale priorities?

A Not to my knowledge, sir.

Q -- As among environmental concerns?

A NOt to my knowledge, sir.

Q No. Did you establish a board of independent assessors made up of wildlife people to determine these disputes between the caribou people and the bird people?

A No, sir.

Q And I take it in this almost impossible example on the northshore, in the end, both the caribou people and the bird people were furious at the result?

A I think that might be too strong, sir -- I --

Q Were very upset --

A Yes, that is probably true.

Q Yes, and is this not the kind of thing that happened to you with fair regularity, the environmentalists each with their own particular areas of concern, were unable to resolve their differences because they had different areas of concern and you were forced to mediate or make compromises or just strike a decision to have done with it?

A That is correct.

Q Yes. And I put it -- it is obvious -- that in many instances that satisfied nobody.

A I am not sure of that, sir, because there are further things that can be done. First, with respect to the construction and operation of a section of pipe rather than compressor stations --

Q I am sorry, I should have referred to that in fairness to you. You say that route selection is only one of the things -- that there are design and operation features that may ameliorate the impact on birds and caribou and so on --

A And construction scheduling --

Q Yes --

A -- and so on. There are other factors that must be considered.

Q But I take it that in this environmental meeting, you were either babes in the woods or Alice in Wonderland, in terms of having any guideline with which to make a decision?

A We received no guidelines from the client or anyone, sir.

Q And you were unable to devise any?

A That is correct.

Q Well, now, in the course of these hearings, we no doubt will be hearing from many environmentalist and socio-economic people who will express their views about the impact of your pipeline and you expect that, do you not?

A Yes, I do.

Q Yes, and I take it that it is conceivable that you will hear much evidence that raises perhaps for the first time, environmental or socio-economic considerations, that notwithstanding

your efforts, have not come to your attention?

A That is certainly possible, sir.

Q And I take it that it is the posture of Northern Engineering -- we will deal with Arctic Gas later, but we can only deal with Northern Engineering now -- it is the posture of NOrthern Engineering that it will listen carefully to these concerns?

A We will.

Q And that it will attempt to respond by way of devising solutions for them where possible?

A Yes, we have done that.

Q Yes, and you will continue to do that.

A And will continue to do that, yes.

Q And I take it that you will -- we don't want you to turn your whole work force upside down, but that you will attempt to devise solutions where possible for these problems that are consistent with good engineering and good economic practice?

A Yes, as long as you include the construction scheduling and the engineering function, yes.

Q And as those things are done, if they are done, as I take your word for it, you will respond with those suggestions, alternatives,

and proposals to the Commission?

A To the best I can, sir.

Q Yes, so that -- just so that I will understand the situation -- as the hearings proceed there will be -- you will be listening and will be responding where possible?

A Yes --

MR. MARSHALL: Perhaps I can be of some assistance here. Certainly they will be provided with a copy of the transcript and I am sure that you will be hearing through Mr. Genest from time to time -- I am not sure what beyond that you are asking for, Mr. Scott.

MR. SCOTT: Well, what I am suggesting -- I would not have thought that there was any doubt about it as a matter of public posture, that the applicant will listen to what is said and will attempt as we go along to devise, either design or routing alternatives that will take account of the problems raised, without interferring unduly with economic or security considerations.

MR. MARSHALL: I think that is so.

MR. SCOTT: Very good.

Well now, let me come to one other matter that I do not think I understand and that is about compressor stations, because I want to get some idea of the flexibility that is here and I understand that, to use the simplest example, which is the one that always occurs to me, compressor

stations are like beads on a string -- spaced at predetermined intervals -- would that be correct?

A Their spacing depends on some detailed mathematical calculations and can be very precise if you know the profile of the pipeline.

Q Yes, and so they -- when the hydraulic calculations have been made with some very great precision you can determine not only where the compressor stations may be sited, but where they must be sited, for efficient operation?

A That is correct.

Q Yes. And I think you told us the other day that if the strings tilted uphill there is a slight variation?

A That is correct.

Q The compressor stations generally speaking must move a little closer together?

A Yes.

Q And when the pipe is tilted downhill there is a slight variation -- they can be slightly further apart?

A Yes.

Q Now, I take it that the cross-delta route and the Simpson route are not -- if they are adopted -- are not going to alter the location of the compressor stations that are shown in the valley? I put that --

A The compressor stations obviously -- on the cross-delta route -- cross-delta change involves a change in the pipeline location

down to the Thunder River area and in that instance of course the stations move laterally From Thunder River to near Willow Lake -- Willow Lake River, the stations do not change. Because of the Fort Simpson change, the stations have moved laterally and of course are shown in the revision to the application, but the effect of installing the cross-delta will not change those locations south of Thunder River.

Q Well, let me ask you this, on the alignment sheets you showed us the other day the designation for compressor stations.

A Yes.

Q Are those compressor stations, bearing in mind the scale of the alignment sheet, precisely sited?

A Bearing in mind the scale, yes -- No I am sorry, let me back up -- I believe there had been some locations that had been moved within the half mile we discussed earlier. IN other words, if the examination of a photograph with a stereoscope indicated that we were right in the middle of a lake, we moved them, obviously.

Q So would it be correct to say that they are generally sited --

A Generally sited, sir. --

Q -- within a mile or two but not precisely sited?

A I am sure the locations are not the precise mathematical location, that is what I am trying to say. There has been some judgment

used in examining the terrain to see whether a station could be built at that location.

Q Well, now, the question that I was asking, we have the alignment sheets for the central Mackenzie Valley.

A Yes --

Q What I am asking is are the amendments proposed at the delta, the cross-delta route and the Fort Simpson route change, going to alter, if adopted, the placement of the compressor stations for the rest of the Valley as shown on the alignment sheets.

A No.

Q Well, now, one other factor about flexibility. You told us the other day that -- dealing with questions of movement of compressor stations -- that you could move one half a mile up - hill and did you say two miles downhill without endangering the hydraulic efficiency of the operation?

I can't put my finger on your evidence but I think you dealt with it.

A One moment, please.

Q I think you said upstream and downstream rather than uphill and downhill.

A Sir, I was quoting from a response to question 16, in the responses to the Assessment Group.

Q Did I have the figures right?

A That's just what I'm checking.

Q Oh, I'm sorry.

A Well, sir, we give an example of the effect of moving a station either half a mile upstream or half a mile downstream, and I think the problem that comes about, I was trying to illustrate that under certain circumstances, the movements could be more than that, and perhaps didn't explain it too well. The -- you have to visualize that the pressure level in the pipeline varies from 1,680 pounds discharge at the station to something on the order of perhaps a number of 1,400 pounds at the next station. Again I'm not being precisely correct, but for illustration you could then determine the pressure in the pipeline, above any point along the pipeline, between those two stations. It obviously decreases as it goes to the next station, and that has a certain slope, that pressure gradient has a certain slope. Now if in fact the location of the downstream station is on terrain

that has essentially the same slope, you have more flexibility in moving, you could move it further. If the terrain at that station was at the same slope as the pressure gradient, and I think off the top of my head I suggested that in that particular instance you might be able to consider two miles, I'm not aware of such a location, I was using it as an example.

I also said that when the converse was true, that you had a lot more trouble, the half-mile was not appropriate.

Q Yes. Well now, I take it that there's another restriction we should have out, and that is that if you already moved the compressor station upstream, then you have no flexibility with respect to the one immediately --

A That's correct.

Q --ahead of it.

And in that sense it's like beads on a string, each of which must be relatively speaking, a particular distance from each other.

A Yes sir.

Q Now you said in your evidence that there was no restriction on lateral transfer. Let me just ask about that because I was a little surprised by that answer, and perhaps you didn't intend it in that context. I take it in the first place the compressor station must be reasonably adjacent to the pipe.

A I thought I had cleared that up. I recognize the error.

Q Isn't that so?

A Yes.

Q You can't have it a couple of miles from the pipe, or can you?

A The illustration, or an illustration to demonstrate what I meant is the Fort Simpson change, for instance it involves several hundred miles of pipeline. We have the same number of stations, we didn't significantly change the length of the line but we moved them all laterally. You obviously have to move the pipeline every time you move the station laterally.

Q So in lateral movement the key is that the compressor station must be on the pipeline.

A Yes sir.

Q And the second restriction I take it, is that if your lateral movement increases the length of the line substantially, you will have to put in or you may have to put in an additional compressor station.

A That situation could arise, or you would be required to change the location of several of the adjacent stations.

Q Yes. Well now, you told us that the delta and the Simpson route change were developed over the last year, in one case, year and a half in the other. May I ask when, with respect to both of them, when your socio-economic consultants went to work on those route changes?

A We do not have any socio-economic consultants, sir. The information has been provided to CAGSL staff, and I would assume that they have been aware of it.

Q Well, let me put this to you. I understand that you don't retain the socio-economic consultants. When did you let your environmental consultants know about these proposed route changes?

A Perhaps Mr. Williams can respond to it in time frame better than I.

WITNESS WILLIAMS: Well, with respect to the cross-delta routing, when the study began seriously in the fall of 1973, the environmentalists were made aware of it, very close to the same time, and they started on a literature search of possible difficulties in that area.

With respect to the Fort Simpson re-alignment, which we said started -- my mind's gone blank about dates, but they were advised at about the same time that we started studying it seriously from an engineering aspect.

Q And did you take any steps to alert Arctic Gas to alert its socio-economic consultants that these changes were in the works?

WITNESS DAU: Not specifically, I don't think, sir.

Q You would agree with me that that would be important, wouldn't it, that they should get their socio-economic input in on those two

route changes as early as possible?

A I agree with you, sir, but you must recognize that we work very closely with the staff of Canadian Arctic Gas, and it's not a case that we go off and do things in isolation and report back months later. There is constant dialogue between us.

Q But in respect of the Fort Simpson route change, you or the applicant, as you will note from his application, respecting it says that the socio-economic impact of the original Fort Simpson route and the alternative route are about the same.

A I've read that, sir.

Q Yes. Do you know from whom that socio-economic analysis came?

A I do not.

Q Don't you know who Arctic Gas has retained to give them socio-economic advice on the Fort Simpson route change?

A Yes sir. They retained Gemini North in the past.

Q Do you know who they retained on the Fort Simpson route change?

A Not specifically. I cannot recall the name of the other consultant.

Q Well, perhaps Mr. Marshall can let me know later who that was. You're not a sociologist, or an economist, but you have told us that it was important or that it was judged to be important that an appropriate distance be kept from

established communities when you're setting up the line.

A Yes.

Q And I take it that there are two factors inherent in that. One is that if you go within a certain distance of a community you have to have a certain dimension -- I shouldn't say "dimine-sion" but a certain depth or width of pipe.

A "Wall thickness" is the word you're looking for.

Q Wall thickness.

A Yes.

Q So there would be an economic virtue in staying, as we have used the phrase, at an appropriate distance from the communities.

A Yes.

Q What is the appropriate distance in terms of changing the wall thickness of the pipe, do you know that?

A It's a matter of the codes that are used for design of pipelines in Canada and United States, and it involves a population density count along the pipeline route. I could get you the precise information, if you like.

Q It's apparent, isn't it, that the appropriate distance in terms of wall thickness is on a scale based on population density?

A Yes, that's correct.

Q And I take it that that has been the only guide that you have had, or your

firm has had in determining the appropriate distance from communities.

A I would think so, sir, yes, with one -- recognizing, of course, in the back of your mind the potential expansion of the community.

Q Yes.

A In other words, you could precisely locate a pipeline today by a community, and not have to worry about a re-design of the system, and then be in trouble four or five years from now when the community expanded. If you put that into the --

Q But that's also an economic consideration, isn't it? You don't want to have to dig up that pipe and replace it with a thicker wall when the community gets bigger.

A I would say that it's economic in its main sense, yes. It could also restrict the expansion of the community to a degree.

Q But I take it that as you had no socio-economic consultants, your recommendations to Arctic Gas with respect to the placing of the pipe in relation to communities was based on the consideration which you've outlined.

A Yes.

Q Yes, and on that alone, you having no socio-economic consultants?

A The precise location with respect to the community is also dependent on -- I think you understand -- is also dependent upon other things such as if we outlined in route selection, in

other words, we don't -- that affects the route. We didn't specifically change the pipeline route because of the location of the community. I'm not sure I understand you yet.

Q A sociologist might be able to fix in sociological terms the distance a pipeline and its social impact should be from a community, you understand that theory?

A Yes, I understand.

Q You didn't have any of that input.

A No sir.

Q And therefore I put it to you that your recommendations to Arctic Gas on the appropriate distance from communities was dictated by the problems of pipeline construction and economics exclusively.

A I think the answer to that is "yes," but I must tell you that in no instances was the pipeline logically located so close to the communities that we would have to consider the redesign of the wall thickness. The logical location that we have, you know, that we were not conscious of that particular thing because it didn't occur.

Q Your main consideration in this area was economic and engineering.

A Yes sir.

Q Entirely.

A Yes sir.

Q And it will be a happy accident that the sociologists will agree with your placement of the pipe in relation to communities.

A I imagine that's true, sir, yes.

Q Well now, I take it that the compressor stations are at least, in human terms the most offensive part of the pipeline. How can I ask that question of a pipeline man? But I take it that they're noisy and they're busy.

A No, I would disagree, sir. Busy, but I don't understand your term "busy".

Q Let me put it this way. Have you formed any judgment as to whether --I ask you this as a human being first of all, whether a length of pipe six feet in the ground is less offensive than a compressor station with the travelling to it and the noise and so on that may come from it?

A In that sense I understand your question, yes.

Q And you will agree with me that in that sense the compressor station is busier an d noisier.

A Yes, it's certainly noisier than buried pipe, and certainly people visit it

far more than they visit buried pipe.

Q You're making fun of me.

A No, I'm not. No, I'm not.

Q Now, that's particularly so in this case, is it not, because the compressor station site, with certain exceptions, is going to be used as the construction site.

A That's correct.

Q Yes, and the borrow locations, insofar as possible, are going to be located as close as possible to the construction site.

A Yes.

Q So that at least during the period of construction, the compressor station is going to be, and its environs, is going to be a very busy place indeed.

A Yes.

Q Well now, the Fort Simpson,the original Fort Simpson route, the route and the nearest compressor station, I am advised, was about 20 miles from the community. Would that be approximately right?

A I'll accept that, sir. The pipeline is about that far away, yes.

Q Well, I' m telling you because I've seen it on the map.

A Yes sir.

Q But under the route change, the compressor station and the construction

site are immediately adjacent to Fort Simpson, across the river.

A May I get the map out, please? It's about eight miles away, sir, I believe.

Q On the first drawing? On the original?

A No, I'm talking about the revision east of Fort Simpson, the station is north of the Town of Fort Simpson, and by road, my rough scale would indicate that its about eight miles.

Q Wouldn't it be correct to say that its across the river?

A Yes, it's across the river, sir.

Q It's almost Fort Simpson north --

A No, no, I'm sorry. The compressor station itself is more than four miles from the river, on the north side of the river., and looking at the map I would say that it's almost directly north of Fort Simpson.

Q All right.

A The access road to the site would be a distance of five miles or more to a dock on the north side of the river.

Q Well, let me put this to you. The heli-pad and the road and the construction camp and the compressor station and the wharves and the whole exercise are going to be within four to eight miles of Fort Simpson under the new plan.

A That's correct, sir.

Q Well, and you agree with me that these socio-economic consultants to Arctic Gas have said that that change doesn't alter the socio-economic balance between the two alternatives?

A That's what the application says, yes sir.

Q Now you're not a sociologist and neither am I, but can you as a layman understand that? That's pretty tough to understand, isn't it?

A Can I look at the original mileage sheets? On the route east -- sorry, on the route west of Fort Simpson the compressor station is about 20 miles from Fort Simpson. It was connected to or had access to Fort Simpson via the Mackenzie Highway and a permanent road was constructed for a distance of some ten miles to the station. The station, that is on the east of Fort Simpson route, is -- I'm guessing -- about eight miles from Fort Simpson, and has no direct access by vehicle.

Q Well, there's going to be a boat crossing by Arctic Gas, isn't there?

A Yes sir.

Q Of course.

A And the argument we have, sir, then is the difference between eight miles and 20 miles.

Q Well, I put it to you Mr. Dau, as the last matter I want to deal with, that

it's very difficult for anybody to understand how there can be no socio-economic difference when the whole shibang is moved right to the edge of the town.

A I can't agree with you that it's right at the edge of town, sir.

Q All right. You're going to -- are you going to be in charge of construction? Your company.

A In charge of construction?

Q Yes.

A No sir, we perform an engineering function -- design, surveys, route locations and things like that, not in charge of construction, sir.

Q You're going to have trouble preventing those gangs from going into Fort Simpson for a beer.

A Yes.

SCOTT: All right, we'll wait for your socio-economic panel to explain that. That is all the questions I have. Thank you, Mr. Dau.

MR. MARSHALL: Mr. Scott, are there others who wish to cross-examine this panel?

MR. SCOTT: I should say, Mr. Commissioner, that Mr. Templeton has sent us some questions, a few questions. I think I would prefer not to ask them, and Mr. Dau and Mr. Williams at least will be returning shortly, perhaps I should notify Mr. Templeton that if he wishes to ask them they will

be available on the construction panel. I am prepared, as I have said, to ask any questions or to assist anybody in the room who is not one of the major participants, to put questions, and I have not heard from anybody in respect to this panel, but I'm generally prepared to help in that way with any other person, but I am not certain that that should apply to major participants. The risk might be that they'd all go home and hand their questions to me.

THE COMMISSIONER: Well, since Mr. Dau, I take it, will be returning on the construction panel, then I think that I will allow Mr. Templeton at that time to ask his questions about routing instead of requiring you, Mr. Scott, to put them to the witness. I think it's better that Mr. Templeton put his own questions.

MR. MARSHALL: That is fine with us, sir. There was a point that Commission counsel asked me to advise him about, and that pertained to socio-economic advice to Arctic Gas pertaining to the routing revision, east of Fort Simpson. My instructions are that Arctic Gas received advice from Van Dinkle Associates, Mr. Ralph Hedlin, H-E-D-L-I-N, and members of the Arctic Gas staff who had become informed on matters of socio-economic concerns.

Mr. Commissioner, I have no re-examination for this panel.

MR. BAYLY: Mr. Commissioner,

I have one matter that I had raised earlier, and having been assured by Mr. Marshall and his witness that I can inspect the alignment sheets with the corrections or up-datings that Mr. Watson has, and also having been assured that there is even more recent information available, I do not wish to further this point in cross-examination at this stage.

THE COMMISSIONER: Q Mr. Dau, the application for a right-of-way by Arctic Gas has all along described the coastal route from Prudhoe Bay along the north slope to the Canadian border, then across the Yukon to Fort McPherson the prime route, and the interior route through the mountains as the alternate route. Now both of those routes were found to be feasible strictly from an engineering point of view, and they were advanced, one as the prime and the other as the alternate route.

WITNESS DAU: That is correct, sir.

Q The route along the coast is preferred because it is 550 million dollars cheaper to build it on the Alaska side of the border than it is to build the interior route, is that right?

A From the -- those were the numbers I gave you yesterday, yes, I believe that's correct, sir, if I could dig them out.

Q Well, I don't think you have to dig them out. You said that it was $550 million costlier to build the interior route on the Alaska side --

A That's right.

Q -- or cheaper to go along the coast on the Alaska side.

A Yes.

Q Now, is that the reason why the coastal route was chosen over the alternate route?

A That would be one of the main considerations. There are other considerations with respect to operation of the pipeline. The interior route would be more difficult to operate but it's feasible. In that sense it's more expensive and more difficult to operate.

Q Well, first of all it is from a financial point of view $550 million cheaper to construct on the Alaska side of the border.

A That's correct.

Q Secondly, you say that from an engineering point of view there are advantages to the coastal route.

A Yes.

Q Are there any other reasons that you know of why the coastal route is preferred as the prime route by Arctic Gas over the interior route?

A There are some environmental considerations, sir, which I believe will be discussed in detail with the environmental panel.

Q Now, the -- you told Mr. Scott that the route across the Mackenzie Delta, across the mouth of the Mackenzie Delta has been under consideration since the fall of 1973.

A That was active consideration,sir. I have difficulty in determining when it -- to define between a preliminary and a very serious look at something and --

Q But you used the words "Active consideration".

A Yes, that is correct, sir.

Q Was the -- has the cross-delta route, that is the route across the mouth of the Mackenzie Delta been under consideration since -- under active consideration since the fall of 1973?

A Yes, sir.

Q Now, does that mean that since the fall of 1973 you yourself would have had it under active consideration?

A Yes, sir.

Q And the people to whom you report at Arctic Gas would have been aware that it

was under active consideration by the fall of 1973?

A Yes, sir.

Q Can you tell me who you would report to at Arctic Gas?

A In that time frame, Mr. Harvey and more currently, Mr. Stark.

Q And what was Mr. Harvey's position?

A Vice-president of engineering and construction, I believe.

Q And what was Mr. Stark's position?

A Mr. Stark is relatively new. He is the General Manager of engineering and construction.

Q Well, now the Fort Simpson route. How long ago was it that the Fort Simpson -- that the alternate route, the so-called Fort Simpson amendment to avoid the crossing of the Liard. How long ago was it that that route change was brought under active consideration?

A It came under active consideration at the time of the decision to install the dual river crossings on the major rivers and that time frame is -- we could get that date quickly for you -- it -- if my memory is right, it was spring of '74 or very early '74, but I would have to confirm that particular date.

Q Well, let me put it another way. When was the concept of dual pipes under the

major river crossings first brought under active consideration?

A Just immediately prior to that, sir.

Q Without tying yourself down to a specific date or even month, what period was that?

A It would be the spring of '74, sir. It would be -- essentially the two times coincided, once that decision was made it became very apparent that the cost advantages swung to the other route, within a month or so in that time frame.

THE COMMISSIONER: WEll, thank you very Much Mr. Dau, Mr. Williams, Dr. Mollard, and Mr. Watson. We all appreciate that you have come and have been so patient with all of the counsel who have questioned you and have been so patient wth with me as well. I understand we may be seeing all of you again and certainly one or two of you again and should look forward to that.

We will adjourn until two o'clock on Monday afternoon and the INquiry will sit from two until five on Monday afternoon and then from eight until ten on Monday evening. From two to five Monday afternoon and from eight until ten Monday evening and then on Tuesday we will start at nine o'clock in the morning again. So we stand adjourned.

(PROCEEDINGS ADJOURNED TO MARCH 17, 1975.)

MACKENZIE VALLEY PIPELINE INQUIRY

IN THE MATTER OF AN APPLICATION BY CANADIAN ARCTIC GAS PIPELINE LIMITED FOR A RIGHT-OF-WAY THAT MIGHT BE GRANTED ACROSS CROWN LANDS WITHIN THE YUKON TERRITORY AND THE NORTHWEST TERRITORIES FOR THE PURPOSE OF THE PROPOSED MACKENZIE VALLEY PIPELINE

and

IN THE MATTER OF THE SOCIAL, ENVIRONMENTAL AND ECONOMIC IMPACT REGIONALLY OF THE CONSTRUCTION, OPERATION AND SUBSEQUENT ABANDONMENT OF THE ABOVE PROPOSED PIPELINE

(Before the Honourable Mr.Justice Berger,Commissioner)

Yellowknife, N.W.T.

March 17, 1975.

PROCEEDINGS AT INQUIRY

VOLUME XIX

ALLWEST REPORTING LTD.,
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BURNABY 2, B.C.

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Mr. Pierre Genest, Q.C. Mr. Jack Marshall, Mr. Darryl Carter, and Mr. John Steeves	for Canadian Arctic Gas Pipeline Limited;
Mr. Reginald Gibbs Q.C. Mr. Alan Hollingworth	for Foothills Pipelines Ltd.;
Mr. Russell Anthony, Prof. Alastair Lucas & Dr. Andrew Thompson	for Canadian Arctic Resources Committee;
Mr. Glen W. Bell and Mr. Gerry Sutton	for Northwest Territories Indian Brotherhood and Metis Association of the Northwest Territories;
Mr. John U. Bayly	for Inuit Tapirisat of Canada and the Committee for Original Peoples' Entitlement;
Mr. Ron Veale and Mr. Allan Luke	for Yukon Native Brotherhood;
Mr. Carson H. Templeton	for Environment Protection Board;
Mr. David Reesor	for Northwest Territories Association of Municipalities
Mr. Murray Sigler	Northwest Territories Chamber of Commerce

INDEX

TRANSCRIPT CORRECTIONS (Mar. 7 - 13)

1. March 13, 1975, Vol. XVII

Page 1918.	Line 11.	Should read:	"Q. Two borrow pits."
" " .	" 23.	" " :	"Q. Two borrow pits."
" 1919.	" 9.	" " :	"Q. Two more borrow pits."
Page 1939.	" 15.	" " :	"Conflict is different. In some..."
" 1936.	" 22.	" " :	"....results be obtained."
" 1940.	" 15.	" " :	"Louis or Willy Yendi...."

Glen Bell

Yellowknife, N.W.T.

March 17, 1975.

(PROCEEDINGS RESUMED PURSUANT TO ADJOURNMENT)

MR. SCOTT: I wonder if I could make of the applicant, a request for information that we would like to have at a time convenient to him, just so that he will have a record of it, I thought I might read it into the proceedings?

We have three requests for information that apply to that portion of the pipeline within the Yukon and the Northwest Territories only, and the first is:

1. What is the total mileage of the applicant's original prime route including laterals affected by subsequently proposed alternatives and amendments?

I think here we're thinking principally of the cross-delta alternative which is proposed, and the Fort Simpson route change, which has already been filed.

2. Assuming the cross-delta alternative and the Fort Simpson amendment, and any other relevant proposed changes, what is the total mileage of the applicant's route including laterals?

Also for comparison we would be grateful for the total mileage of the original prime route.

3. Assuming the cross-delta alternative, the Fort Simpson amendment, and any other relevant proposed changes, what is the total mileage of the

route which will not be covered by bore holes located within the limits of the mosaics on the applicant's alignment sheets, and with the frequency of at least one bore hole to every three miles?

Now I think those questions will be clear -- Mr. Genest is shaking his head --

MR. GENEST: Well, I presume I will have access to him explaining to me.

MR. SCOTT: You will have access to me to have them explained, and I think the record when it's reviewed will reveal precisely the information we would like, and I'd be grateful to him if he could take under consideration providing that to us.

MR. GENEST: Certainly.

Mr. Commissioner, before I call my next panel, we undertook on Friday to inform ourselves over the weekend as to the source of information that was given to Mr. Williams in cross-examination by Mr. Bayly with reference to trappers in the Old Crow area, and I have a letter from which I am informed the information came. The source of the information was the Government of the Yukon Territory, and was contained in a letter dated July 31, 1973, written to our Mr. D.M. Fox or to Mr. D.M. Fox of the Northern Engineering Services Limited by Mr. J.B. Fitzgerald, Director of Game of the Government of the Yukon Territory, and perhaps I should read it. It says:

"Dear Mr.--"

and it's dated, I think I gave the date, July 31, 1973, it says:

"Dear Mr. Fox:

In reply to your letter of July 6th we have enclosed a photo copy of a map of the Northern Yukon showing the Old Crow group trapping area, the Fort McPherson NorthWest Territories group trapping area, the Fishing Branch Game River Preserve and the Peel River Game Preserve. That portion of the Yukon between the Old Crow group area and the coast is reserved for the hunting and trapping activities of natives from the Aklavik and Tuk area, who have traditionally hunted and trapped in this area. One family, resident on Herschel Island, also utilizes this area. There are approximately 50 trappers in the Old Crow group area, but only five or six in the Beaufort Coast zone. During the past two years, only two serious trappers in this zone worked the coast line."

It's signed by Mr. Fitzgerald, and that was the source, sir, of Mr. Williams' information.

With that, sir, may I call my numerous next panel? I hope it doesn't out-number the audience. Be seated, gentlemen, please.

Before you do, Mr. Williams is on this panel, sir, and I just notice was not listed on the names of witnesses that were furnished

with the summary of evidence. Mr. Williams is on the panel really for the purpose of dealing with our -- mainly for the purpose of dealing with our test facilities, because he was the supervisor. He's already been sworn.

Perhaps if I could name them from my left, we start with Dr. Cooper. Next to him is Dr. Garry Hollingshead, next to him is Dr. William Alexander Slusarchuk, next to Dr. Slusarchuk is Dr. R.M. Hardy, next to Dr. Hardy is Dr. John I. Clark. Next to Dr. Clark is Dr. Morgenstern, Norbert Reuben Morgenstern. Next to Dr. Morgenstern is Dr. Edward Charles McRoberts and of course next to Dr. McRoberts is the only Mr. on the panel, Mr. Williams.

THE COMMISSIONER: Welcome back Mr. Williams.

MR. GENEST: May they be sworn, sir.

RICHARD H. COOPER, sworn.

GARRY WOOD HOLLINGSHEAD, sworn.

WILLIAM ALEXANDER SLUSARCHUK, sworn.

ROBERT MCDONALD HARDY, sworn.

JOHN IVOR CLARK, sworn.

NORBERT REUBEN MORGENSTERN, sworn.

EDWARD CHARLES MCROBERTS, sworn.

GUY LESLIE WILLIAMS, resumed.

THE COMMISSIONER: Mr. Genest, before you begin questioning these witnesses, I thin k I should tell you that I have received a letter from New York, New York, from a gentleman who obviously has this INquiry in proper perspective. He

has written me a letter, Commissioner of the Mackenzie Valley Pipeline Inquiry. He says:

"Enclosed is a clipping from the New York Times"

He says:

"I am interested in the handstiched moccasins of the Indians. Could you help me to get a pair or two. I will pay for them when you let me know the cost. I wear size 9 or 9 1/2 medium width. If you cannot oblige would you please pass this note on to someone who can. Thanking you in advance, ..."

Well, that gentleman is not getting overcome by the --

MR. GENEST: I wonder if as with the previous panels, sir, I might file as an exhibit, the next exhibit number, the set of resumes setting up the biographical data on each of these witnesses. I have already handed a copy of that to Miss Huthinson and the participants, I believe, have that resume which was provided with our summary of evidence. And while I am filing paper I would also like to file, sir, what was called appendix "c" to the summary of the evidence of this panel which is a list of reports to which they have referred or upon which they may rely.

(RESUMES OF BIOGRAPHICAL DATA MARKED AS EXHIBIT NO. 76.)

(APPENDIX "C" MARKED AS EXHIBIT NO. 77)

MR. GENEST: There should be added to this list three reports which I

described to the Commission last Wednesday and perhaps I could name them again. The first was a report on drainage and erosion control -- that is E.R.O.S.I.O.N. -- I see that I was quoted in the transcript as referring to rodent control and we do not have a panel dealing with that.

The second was called a draft interim report on results from frost effects study, the third was a reference book of water crossings, volume VII, "Supplemental Hydrology". I now, sir, wish to advise my friends and you that we have received again two fresh additional reports that have just come into being, both prepared or contributed to by members of this panel and upon which we will be relying. ONe is called a report on foundation design and its formal date is February 1975. The second is called, is entitled, "Reconnaissance of the Aleyska Pipeline", and I have two copies here of this report available for inspection by any of the parties and Commission staff. But those should be added to the list of reports in Appendix "C".

I have also handed to the Secretary of the Commission what is referred to in the summary of evidence as Appendix "B" which is a -- what would I call that? -- a treatment of the technical studies, a list of the technical studies in the geotechnical area which were conducted by or under the supervision or for the use of this panel and if that could receive an exhibit number.

(APPENDIX "B" MARKED AS EXHIBIT NO. 78)

There was an error on page six of that material. When I handed it out to my friends there should be a new page six which I inserted in the copy given to Miss Hutchinson and I have distributed a copy of the new page six to the participants and to the Commission Counsel.

Perhaps now, sir, I could move on to the qualifications and experience of the panel and I would like to start with Dr. Clark ---

MR. SCOTT: Mr. Commissioner, before my friend does could I just deal with the question of reports. We recognize that the scientific work is ongoing and/that there will be reports produced from time to time on various matters. It is a very difficult matter, however, when three reports nicely bound thereby indicating their availability some time ago, let us say, ten days ago are produced two days before and then on the very day of the INquiry. It makes it very difficult to consume and understand anything in those reports and to conduct any kind of cross-examination. I would hope that my friend in the future, if the report is not bound in some permanent form will take steps to at least make one copy available in the unready state so that it can be examined by those people who have some interest in this subject matter.

MR. GENEST: I will do that, sir.

MR. SCOTT: It seems to me that in this case, assuming that there is anything relevant in those reports as I am sure that there is and which the panel relies, it will be virtually impossible to conduct any significant cross-examination with respect to it.

MR. GENEST: Well, I know the problem. I hope my friend appreciates our problem. The work is on-going, it is in peoples' heads and then gets reduced to paper and then is issued as a report. If there is prejudice caused by the lack of having that report in hand in good time, I'm sure any of the parties or all the parties who have suffered that prejudice will apply to you, sir, for some time to digest them and I'll have to bring the panel back if they make out a case of prejudice; and I appreciate that and when these come out I undertake to -- or when I hear that they're coming out, I undertake to get at least some advance notice or copies just as soon as I can.

Q Dr. Clark, you are, I understand -- first of all you're sitting in the middle, you should raise your right hand and identify yourself -- you're the supervisor of geotechnical and environment studies for Northern Engineering Services Company Limited.

A That's right, sir.

Q And I understand that you received a B. Sc. in Mathematics and Physics from Acadia University.

A Yes sir.

Q You then received a Bachelor of Engineering from Nova Scotia Technical College, which is where everybody in Nova Scotia goes to get that kind of degree?

A That's right.

Q You received a Master of

Science in Civil Engineering from the same institution.

A Yes sir.

Q And you received a Doctorate in Civil Engineering from that institution in 1970, your specialty being soil mechanics and foundation engineering.

A The Master of Science was from the University of Alberta.

Q Oh, I'm sorry, I overlooked that, yes. And you belong to the usual Associations of Engineers?

A Yes sir.

Q And you were a member of the Organizing Committee for the Third International -- it says here, "Society of Soil Mechanics & Foundation Engineers", I understand that's an error.

A It's the Third International Conference on Permafrost, which is upcoming.

Q And what kind of conference is that, sir?

A It's held every three to four years. It was held last year in Yakutskt , Russia. Next time it will be held is in 1978 in Edmonton, Alberta.

Q And I take it it discusses permafrost, that's self-evident?

A Yes, from several points of view.

Q From an engineering, as well as--

A Engineering, geology and glacialogy and so on and so forth, included.

Q You're an associate editor of the Canadian Geotechnical Journal?

A Yes sir.

Q What is that publication, sir?

A That's a publication that is officially put out by the National Research Council. It serves more or less as the voice of the geotechnical community in Canada.

Q How long have you been in that capacity?

A About two years, I believe.

Q And you're the first Albertan to be elected a director of the Canadian Geotechnical Society, or have I got that wrong?

A That's correct. There is a director from several regions in Canada, and I'm the director for Alberta.

Q And from 1957 to 1960 you were with the Royal Canadian Air Force in charge of construction projects in the Arctic and sub-Arctic.

A That's right, sir.

Q And what were some of the projects you worked on?

A Well, I spen t about seven months at Whitehorse,principally involved with the construction of buildings. The larger component of that period with the Air Force I was at a mid-Canada

line site in Hudson's Bay where we constructed a wharf, inland training basin, some pipeline, buildings and where we did a number of engineering studies, many of which were related to permafrost problems.

Q And thereafter, sir, you were a project engineer with the Soil Mechanics Division of the Department of Public Works in OttawA?

A Yes sir.

Q And your reponsibility there related to what?

A Project engineer for foundation studies for Federal Buildings, slope stability problems on federal land and so on.

Q Then for ten years thereafter you were chief engineer and head of the Geotechnical Division, Materials & Testing Laboratories with R.M. Hardy & Associates?

A That's right, they were dual companies at that time, Materials Testing Laboratories and R.M. Hardy Associates, and they were merged a few years ago under the one name of R.M. Hardy & Associates.

Q And R.M. Hardy is the gentleman sitting to your right.

A That's right, sir.

Q And what was your work there, sir?

A It was practically all of a geotechnical and engineering nature, foundation engineering, slope stability work, some engineering

geology and rock mechanics, some permafrost work, quite a wide variety of geotechnical studies and work.

Q And since 1972 I understand you've been with Northern Engineering Services Company Limited.

A That's right, sir.

Q And associated with this project.

A Yes sir.

Q Were you associated with it in any way before you came to Northern Engineering?

A I was officially seconded to Northern Engineering at about December 15, 1972, and for some time -- a few months prior to that time I had discussions with some geotechnical people there, as well as within the Pemcan group, related to studies that were being undertaken at that time.

Q And the schedule you've filed shows that you're the author responsible for ten publications, one of which was awarded the Canadian Geotechnical Society prize.

A That's right, sir.

Q And what was your area of responsibility in connection with the Arctic Gas Pipeline project?

A I supervised the geotechnical engineering as a component of the Northern Engineering staff and in 1974 the Environmental Group was merged with the Geotechnical Group, and I served

as supervisor of the combined group at this time.

Q Could I then turn, because it's the next one in my notes, to Dr. Hollingshead? You're the second from the left, Dr. Hollingshead, and your present position is as manager of River Engineering in the Northern Engineering Services Company and you came to there from R.M. Hardy & Associates.

A That's right, sir.

Q And you received a diploma in civil engineering from the Royal Military College in 1959, a Bachelor of Science in Civil Engineering from the University of Alberta in 1960, a Master of Science in 1965 from the same institution, and finally in 1973 you received a Ph.D. in civil engineering from Queens.

A That's right, sir.

Q Is that correct, and that was specializing again in soil mechanics and foundation engineering?

A Yes sir.

Q And your experience briefly, from 1960 to 1963 was in the field in the military field, military engineering, is that correct?

A That's right, with the Royal Canadian Engineers.

Q And you spent one of those years on the Northwest Highway System .

A Yes sir.

Q What is that, Dr. Hollingshead?

A That was the name applied by the military to the Canadian portion of what is commonly known as the Alaska Highway, and up until about 1963 the Department of National Defence was responsible for the maintenance of that particular highway. I was involved with that project.

Q And from 1965 to 1973 you were a professor of civil engineering at the Royal Military College, is that right?

A Yes sir.

Q And you did some consulting work in the interim period?

A Associated with a Toronto firm during part of that period.

Q And from 1973 you've been with the -- are you with R.M. Hardy?

A Yes sir.

Q You're not part of the -- are you part of Northern Engineering Services?

A Yes sir, I am with R.M.

Hardy,. seconded to Northern Engineering Services in much the same manner as Dr. Clark.

Q And you published -- you also have about ten publications to your credit?

A Yes sir.

Q There are a list of them in your schedule to your resume, and what was your area of responsibility in connection with this project?

A I have been given the responsibility for the river crossing design work which Northern Engineering is involved in.

Q May I move then to Dr. McRoberts, the gentleman next to Mr. Williams. You are a senior geotechnical engineer with Northern Engineering Services Company?

WITNESS McROBERTS: Yes sir.

Q And you're seconded again from R.M. Hardy & Associates.

A That is correct.

Q And your educational background, you got your B.Sc., your M.Sc. and finally your Ph.D. and we say here from Royal Military College but it was from the University of Alberta. Is that correct?

A Yes, that's correct.

Q You received your doctorate in 1973.

A That's correct.

Q And you belong to the

usual Associations of professional people in your field.

A Yes sir.

Q And from 1968 to 1971 you were with the Canadian Forces?

A Yes sir.

Q What sort of work were you doing, sir?

A First two years I was involved in various aspects of geotechnical engineering work. The last year I was in the Canadian Armed Forces I spent as an assistant professor at the Royal Military College in Kingston. At the end of my stay there at the Royal Military College I went to the University of Alberta to do my Ph.D. work.

Q And from there you went to R.M. Hardy & Associates and then Northern Engineering Services?

A That's correct.

Q And what is your area of responsibility with Northern Engineering on this pipeline project?

A Two areas, slope stability, studies in permafrost, as well as in geotechnical aspects of studies concerned with buried pipelines.

Q And you have again a number of publications that you have written, a number of which I notice are in collaboration with Dr. Morgenstern, who is one of our witnesses today.

A That's correct.

Q I move then to you, Dr. Slusarchuk. I pronounce that correctly, do I?

WITNESS SLUSARCHUK: A Yes, you do.

Q You are with Northern Engineering Services Company Limited via R.M. Hardy & Associates Limited.

A Yes sir.

Q As manager of geotechnical and geothermal studies.

A Yes sir.

Q Would you tell me what that means?

A I am responsible for the various studies in the geotechnical area, such as design of foundations, slopes, pipe flow interaction and so on, and also in the geological area. In the geothermal studies I'm responsible to make sure that we have the ability to predict the temperatures in the ground with regard to this pipeline, and the associated ancillary structures.

Q And you've a B.Sc. and an M.Sc. in civil engineering, and you finally received a Ph.D. in 1971 from Rutgers University in the United States.

A That's correct, sir.

Q And I note that your Master's thesis dealt with frost heave protection.

A Yes sir.

Q And also your PH.D.

thesis dealt with aspects of frost-heaving phenomenon.

A Yes, this is correct.

Q Your professional experience, sir, was spent,devoted firstly again as an officer in the Navy.

A Yes sir.

Q What sort of work did you do there?

A For the first year and a half I was more or less on board ship as a shipboard officer in engineering operations in the Navigations Department. Then I spent about six months as a construction officer designing alterations and additions to ships in the Naval Architect Division, and the last year, approximately for the last year, I spent as base development officer on the Atlantic Coast, and this was invdved with major and minor construction and base maintenance along the Atlantic Coast.

Q Soil and geotechnics, I take it when you were at sea, were something the ships tried to avoid.

A Yes sir.

Q Then you became a research officer of the National Research Council of Canada, is that correct?

A Yes sir.

Q And you spent three years with the National Research Council?

A Yes sir.

Q And wha t was the

direction of your specialty there?

A My research there was mainly in permafrost engineering with emphasis on foundation problems associated with construction of northern pipelines.

Q For the Research Council?

A Yes sir, for the Research Council.

Q And you joined Northern Engineering in 1973.

A That is correct.

Q You didn't come via R.M. Hardy & Associates?

A I joined R.M. Hardy & Associates to join Northern Engineering Services.

Q What was your area of responsibility in connection with the pipeline project?

A My initial responsibility was with regard to the geothermal analysis. Shortly thereafter I was also assigned responsibility for the frost heaving, and more recently I've been given responsibilities in the general permafrost engineering area.

Q And we have a list of some 14 publications which bear your name, is that correct?

A That is correct, sir.

Q Now, Dr. Morgenstern, if I may turn to you, sir, you are presently employed as the professor of civil engineering at the University of Alberta --

WITNESS MORGENSTERN:

A Yes, correct.

Q And you are also a -- carry on practice as a consulting engineer, is that correct?

A That is correct, yes.

Q You have received a Bachelor of Applied Science in Civil Engineering from the University of Toronto -- a D.I.C. -- I forgot to ask you what that was.

A That is a Diploma of Imperial College. It is equivalent to a Masters Degree.

Q Equivalent to a Masters Degree?

A Yes.

Q That is fro m the Imperial College of Science. That is an ENglish institution, is it?

A University of London, yes.

Q And you received your

PhD in Soil Mechanics from that university in 1964?

A That is correct.

Q And you have an enormous number of professional affiliations. Without taking you through everyone of those, I note that you were a member of a -- it is not an expedition -- I do not think that that is the proper word of whatever it is, of civil -- a mission of civil engineers to Yugoslavia to report on earthquake affects?

A Yes, that was about 10 or 12 years ago.

Q You are a member of the editorial board of the INternational Journal of Rock Mechanics and Mining Sciences?

A Yes.

Q You are a member of the editorial board of the Journal of Soil Mechanics and Foundations of the American Society of Civil Engineers?

A Yes.

Q You are a member of the Canadian Advisory Committee on Rock Mechanics of the Department of Energy, Mines and Resources of the Government of Canada?

A Yes.

Q You are also a member of the Associate Committee for Geotechnical Research of the National REsearch Council of Canada?

A Yes.

Q You are a member of the

Canadian National Committeee for Earthquake Engineering?

A Yes.

Q That has nothing to do with causing them, that is --

A Hopefully not --

Q Right.

You are a member of the Earth Sciences Grant Selection Committee, National Research Council of Canada. What does that organization, sir?

A That is one of the Committees that selects the applications seeking funding -- university people seeking funding from the National Research Council to undertake research in the earth sciences. It covers a wide range of activities, geology, geophysics and geotechnical work.

Q You are also a member of the editorial board of the bulletin of the Association of Engineering Geologists.

A Yes.

Q And with Dr. Clark you are a member of the organizing committeee on the Third International Congress on Permafrost?

A Yes, that is right.

Q And sir, your professional experience dates back from 1956 when you were employed for a short while with a firm of geotechnical consulting engineers and then you pursued a course of studies and lecturing?

A Yes, that is right.

Q In 1968 you became Professor of Civil Engineering at the University of Alberta?

A Yes.

Q And you provided with your resume a rather long list of consulting and engagements which in particular refers to a number of engagements on landslides and slope stability .

A Yes.

Q Your experience in pipelines in particular is set out there. You were engaged on the -- with Mackenzie Valley Pipeline Research Limited ?

A Yes, that is correct?

Q Was that for the oil pipeline --

A That was the oil pipeline feasibility study undertaken a few years ago.

Q What was your function in that, sir?

A I established certain design criteria for burial conditions and advised generally on geotechnical aspects of that study.

Q And you have a number of other projects -- E.W. Brooker, Limited -- what was that for?

A That -- when they were the geotechnical consultants to the Gas Arctic Study,

I assisted them on some of their studies at an early stage.

Q The Centennial Gas Pipeline -- it sounds like one of Mr. Gibbs --

A That was a proposal for a Gas Pipeline to Vancouver Island that did not come to fruition.

Q Stone and Webster Engineering Corporation -- you did pipeline work for them?

A Yes, but not in the sense of a gas/oil pipeline -- these were problems associated with marine burial of large diameter pipes off shore for nuclear power plants.

Q And I have a note here -- I do not know if it is listed on the summary, that you have been engaged in connection with the Aleyska Pipeline --

A Yes, I am presently a consultant to Aleyska.

Q And what field of work again --

A With special reference to problems of slope stability and the problems that occur due to thaw beneath the right-of-way. I have also reviewed some other parts of their design for them.

Q And I am not going to take you through your publications. I see there are 59 of them. But there are perhaps more since that -- since

the summation --

A Since this preparation, yes.

Q We are coming to the end, Mr. Commissioner.

Dr. Cooper, I should ask any of my friends who want to address vigourous cross-examination to you to make you move because you are in imminent danger of falling off the platform.

WITNESS COOPER:

A That is correct.

Q You sir, are a consulting professional engineer --

A Yes --

Q And a principal of Northwest Hydraulic Consultants Limited --

A That is right.

Q What is that company, sir?

A It is a firm that specializes in the area of Hydrology and River engineering and also hydraulic model testing.

Q And you are an associate in T. Blench -- B.L.E.N.C.H. -- and Associates Limited?

A Yes, that is an associated company that has similar areas of responsibility.

Q And you have a BSc. and MSc. in Civil Engineering and you have a Doctor's Degree in Civil Engineering which was granted to you by the University of Alberta in 1970, is that correct?

A That is correct.

Q And the area of study which was comprised in your doctoral thesis was what, sir?

A Sediment transport which more simply stated is the ability of flow, say, in a river to move the material on the bed, the ganular material on the bed and the effect of that material on the flow itself.

Q And your professional experience, sir, goes back to 1964 when you became a research associate at the University of Alberta?

A That is correct.

Q In what field did you concern yourself?

A In the same field that my work for the PhD was carried out in -- I also did at that time some commercial model testing while at the university.

Q And then from 1972 you became associated with the two firms we have just named?

A Correct.

Q And both companies I understand offer specialized engineering services in the areas of hydrology and river engineering. -- Perhaps you could tell me what hydrology is -- someone has told me but I have forgotten.

A Well, hydrology is essentially from the point of view of our work, the prediction and analysis of flows, both overland flows,

ground water flows, etc.

Q And your work as a consulting engineer has included the Aleyska project. Were you retained as a consultant on that project, sir ?

A That is right. We were through our associated company, Northwest Hydraulic Consultants.

Q And what did the work for which you/retained to do,encompass? were

A Myself, I was involved in the establishment of design techniques in the planning and supervision of design data collection programs, in carrying out detailed reviews of their actual design . In addition I was charged with the responsibility of supervising our firm's input to the project and our engineers did the detailed/engineering river aspects of the individaul crossing design.

Q And you have listed some four publications of which you are the author, either by yourself or jointly with others.

A That is correct.

Q And you were retained as a consultant to Northern Engineering SErvices?

A Yes.

Q And what was your area of responsibility?

A In many respects similar to that I had with Aleyska, the development and establishment of design techniques, making recommen-

dations for correction of preliminary design data and the requirements -- or the data requirements for ultimate final design. In may cases I have reviewed their reports and made recommendations on these.

Q Thank you. Next if I could move to Dr. Hardy -- from what I read, Dr. Hardy, you are sort of the grandfather of geotechnical business in Canada.

WITNESS HARDY:

A Could be, I --

Q Or do I age you too much?

A Do not worry about that, sir.

Q You were, sir, until 1971 for eight years the dean of the Faculty of Engineering at the University of Alberta?

A Yes, sir.

Q And you are now a Professor Ameritus of Civil Engineering at that institution?

A Yes, sir.

Q Were most of your co-panel members students of yours?

A Not too many of them, sir -- they -- I was actually teaching before their times in most cases.

Q And you are also the President of R.M. Hardy and Associates Limited which

is the firm engaged in the business of -- perhaps you could tell us, describe briefly the business of R.M. Hardy and Associates.

A Well, we're engaged in the engineering aspects of all problems that involve soils, and to a certain extent, rocks. That includes foundations, buildings, and earth dams, highways, railroads, and of course I have personally been interested in permafrost problems for a great many years, dating back to 1944. So permafrost and pipelines, for that matter, are in that field, and are subjects that I have paid a good deal of attention to in the past 20 years, 25 years.

Q And you have a B.Sc. and an M.Sc. in civil engineering.

A Yes sir.

Q You have an honorary Doctor of Science from the University of Manitoba.

A Yes sir.

Q Where you worked in the field of soil mechanics and foundation engineering.

A That is correct.

Q You also have an honorary Doctor of Science from the Royal Military College granted to you in 1972.

A Yes sir.

Q So actually you didn't have to write a thesis.

A I had to do certain other things.

Q I understand that others in this room may be visited by similar doctorates, shortly. You're a Fellow of the Royal Society of

Canada?

A Yes sir.

Q And you belong to the usual Associations of engineers?

A Yes sir.

Q You werea member of the Borden Royal Commission on Energy.

A Yes sir.

Q You were the technical advisor to the Manning Royal Commission on the location of the Pine Point Railway.

A Yes sir.

Q Which involved geotechnical considerations of railway construction in muskeg and permafrost terrain, is that correct?

A Yes sir.

Q And then you're a member of the Alberta Research Council --

A Yes sir.

Q -- and have been since 1948.

A Yes sir,

Q A member of the Universities Commission of Alberta. You occupied that position from '71 to '73.

A Yes, it was then abandoned.

Q You're the past president of the Dominion Council of Professional Engineers.

A Yes sir.

Q A past vice-president of the Engineering Institute of Canada.

A Yes sir.

Q A past president of the Association of Professional Engineers of Alberta.

A Yes sir.

Q I don't know where to stop, Dr. Hardy. You're also a member of a large other number of organizations, and we have listed your academic positions at the University of Alberta, which culminated in your becoming dean of that faculty in 1963. Is that correct?

A I was actually dean of the faculty in 1946, sir, but I left the university in 1959.

Q I'm sorry, Dr. Hardy.

A But then I went back in 1963.

Q What did you do between 1946 -- between 1959 and 1963?

A Well, I was active full-time with R.M. Hardy & Associates, sir.

Q Now you received a number of awards, sir, including the Centennial Medal of the Government of Canada, the Centennial Award of the Association of Professional Engineers of Alberta for 1968, the R.F. Legget Award of the Canadian Geo-technical Society in 1971 -- is that named, by the way, after the Legget who testified here in the

overview evidence?

A Yes sir.

Q You received the Canadian Engineering Gold Medal for 1973 by the Canadian Council of Professional Engineers.

A Yes sir.

Q And I understand that you're also an officer of the Order of Canada.

A Yes sir. I would point out, sir, that you missed a very important one that is most relevant to this hearing, and that is the Keefer Medal of the Engineering Institute of Canada in 1947 for a paper on permanently frozen ground and foundation design, which was the first engineering paper, I think, on permafrost that was produced in Canada. That is probably why I'm here today.

Q In 1947, I'm sorry about that; and your experience, sir, in geotechnical problems and engineering problems has been considerable, I take it. You've worked for the Northwest Study Group, the Gas Arctic project, you helped Canadian Bechtel Limited to do a feasibility study of the oil line on the Mackenzie River.

A Yes sir.

Q You made -- you co-operated or collaborated in your report to the Governor of the State of Alaska concerning the Aleyska Pipeline.

A Yes, I participated in that.

Q You've worked on an Arctic Railway study.

A Yes sir.

Q What did your work consist of in that regard?

A I did an overview of the geotechnical implications of that project, that is the current project that has been considered in the last two years. The firm had one contract for one section, but this -- my responsibility there was to do an overview something like the overview that have been produced for this Commission and were heard in the first two days of the hearing.

Q All right.

A On the general geotechnical implications and problems.

Q And you did some work for a proposed C.N.R. Great Slave Lake Railway.

A Yes, I was heavily involved in that.

Q What was that project, sir? Or that plan.

A Well, it's the railroad that went from close to Peace River, Alberta, to the Pine Point development on Slave Lake, and so that was through country that involved a lot of muskeg and some permafrost, not continuous permafrost but discontinuous permafrost, which can, of course, be very troublesome.

Q What was the degree of

your involvement, sir?

A Oh, I was very much involved in the location of the railroad, and then in special problems, special geotechnical problems such as stability of permafrost and also muskeg problems. I was personally involved in that work myself, I did it myself.

Q You were also involved in the Alaska Highway?

A Yes, that's when I first got involved in permafrost, in fact the term was only invented in the English language a year or two before, I became involved in the Alaska Highway work. We did the first engineering tests on permafrost that had ever been done, I think it's fair to say, on this continent. I did those myself in those days, and that started my interest in permafrost problems.

Q Sir, you were also involved in the development of the townsite for Inuvik.

A I had certain input into that through a firm called Foundation Engineering Company of Canada, who had a contract for design of utilities up there.

Q Were you employed as a consultant?

A I was employed as a consultant to them, yes.

Q And as far as your experience in pipeline projects generally is concerned,

will you run over those briefly? You were involved in the Trans-Mountain Pipeline in what capacity, sir?

A Well, I was consultant to Canadian Bechtel Corporation on geotechnical problems for the Trans-Mountain Pipeline, and that was the first pipeline that the Bechtel Corporation had done engineering on in which they had had any geotechnical input as far as I'm aware, and the Trans-Mountain Pipeline involved a real breakthrough as far as the industry was concerned at that time. It was through very rough mountainous country, and so they considered they should have some geotechnical input but I did this all myself. In other words, I was a one-man team, which is interesting to see the development that's relevant to what's going on here now, in that their work was done by one man. We had no borings. The special problems I looked at for stability problems, river crossings, I had some assistance from others, including Dr. Tom Blench, that has been mentioned from the firm of T. Blench & Associates. I got him interested in river crossing problems, as a matter of fact on the Trans-Mountain Pipeline, and so my involvement included all of the geotechnical work that was done on the Trans-Mountain Pipeline, and of course I've done periodically ever since, have done work on their system involving special stability problems.

Q You were also, sir, involved with the Westcoast Transmission Company in connection with their gas pipeline?

A My participation there

was much the same as on Trans-Mountain and originally was for Canadian Bechtel Corporation.

Q And that traverses difficult country?

A Yes, just as difficult really as on Trans-Mountain, but they came second so that some of the problems were solved.

Q Alberta & Southern Gas Company Pipeline, where is that located?

A Well, it includes the gathering system in Alberta, and some of that work was done directly for Alberta Gas Trunk, other items were done through Canadian Bechtel.

Q Then you acted in connection with Pacific Gas & Electric Gas Transmission Line from B.C. border to the California border.

A That again was for the Bechtel Corporation an d involved special geotechnical problems, and even at that time they were not ever thinking about the scope of geotechnical work being what is being applied to the Mackenzie Valley Pipeline, or any of the Arctic pipeline proposals.

Q You were also, sir, involved with Alberta Gas Trunklines in the construction of certain sections of their pipeline.

A Yes, particularly the line that runs down through the foothills country from up north of Edson, actually, down through Edson and right down to Coleman.

Q Same kind of work again, Dr. Hardy?

A Same kind of work.

Q And you have been engaged as a consultant of the proposed Shell Oil Sulphur Pipeline form Alberta to Vancouver?

A Yes, that was a special project.

Q Is that still in the planning stage?

A Oh, I think it was shelved but it was active at the time and was -- they got to the point of actually preparing design plans. It was fully designed, but they did not have construction plans and that involved of course stability problems and river crossing problems from Southern Alberta out to Vancouver.

Q Did they have a hearing?

A I think they got shot down before the hearing, sir.

Q I have a note that you are also involved in two other pipeline projects, the Northern Pacific Gas Line and the Great Canadian Oil Sands, McMurray to Edmonton line.

A Well, yes, the Northern Pacific is a small gas line that runs from close to Prince George, out to Prince Rupert and they do not have permafrost in there, but they have most other problems that you could possibly have of a geotechnical nature. The Great Canadian Oil Sands Pipeline runs

from McMurray down to Edmonton and they have had one recent development that is of a geotechnical nature and that has -- we are handling that through the firm with -- I have been giving it a certain amount of personal attention as well -- stability of slopes.

Q Your synopsis lists a large number of other projects which I might call not associated with pipelines such as dams --

A That is correct, sir.

Q -- and so on that I will not trouble to take you over with in detail. You are also the author of at least 64 publications which we have listed.

A Yes, sir.

Q Thank you, Dr. Hardy. I may move on now, Mr. Commissioner to the examination of this panel which will follow the synopsis that I have provided to the Commission, my friends.

The first question perhaps inserted at my request, was addressed to Dr. Clark and asks what does the expression "geotechnical" mean?

WITNESS CLARK:

A I understand your request because the word "geotechnical does not appear in any dictionay known to me, but the word "geotechniques"does. And the word "geotechnical" as we use it pertains to "geotechniques". In this sense it refers to the application of scientific methods and engineering principles, to the

acquisition, interpretation and use of knowledge of materials of the earth's crust to the solution of engineering problems.

"Geotechnical" embraces the field of soil mechanics, rock mechanics and engineering aspects of geology, geophysics, hydrology and related sciences.

Q Could we just explain these. What are "soil mechanics"?

A Well, soil mechanics is in essence what used to be what geotechnical is now. We were all referred to at one time as soils engineers. It is in essence the understanding of the behaviour of soils, the mechanical behaviour -- what we call engineering properties, such as strength, permeability, compressability.

Q And why is that relevant, sir, to the construction of the pipeline?

A Well, in particular, this pipeline, one of the most relevant aspects of soil mechanics is the behaviour of frozen soil as we do cross extensive lengths of permafrost. It is also relative to such things as the stability of slopes and foundations for structures.

Q And what in particular is the role of your branch of the science in connection with this pipeline project?

A Well, the geotechnical engineers have been intimately involved with all aspects of the project which relate to terrain conditions.

In the initial stages of the project involvement was with selection of the arctic tests sites and the development of test programs to be carried out at these sites. The route location that currently appears on the alignment sheets was developed by geotechnical personnel working in conjunction with pipeline location engineers and others.

Q What others?

A Oh, they would include, geologists, hydrologists and the staff botanists, plant ecologists, biologists. Geotechnical engineers also deal with the analysis and design for river crossings and slope stability, drainage and erosion control measures, frost heave, pipe/soil interaction and the foundations for compressor stations and ancilliary structures as well as roadways and air strips.

Q Pipe/soil interaction -- I have a little trouble with that expression. What does that encompass?

A Well, this is the inter-relationship between the pipe and the soil when the pipe is buried in the ground. For instance, where the pipe makes abend there is a certain stress in the pipe. At that bend there is what we call a reaction -- that is a force exerted against the ground and that force has to be resisted by the wall of the ditch and we would assess the capability of the wall of the ditch to resist that force. It also involves burial -- depth of burial and the back fill requirements for

certain situations and so on.

Now, the geothermal analysis and geological investigations carried out for the project were also done by or in conjunction with geotechnical engineers.

Q What is geothermal analysis ?

A Well, Dr. Slusarchuk, my colleague on the right, has been most intimately involved in that for several yars and I would ask him to amplify on that.

Q I do not want a great amplification, Dr. Slusarchuk.

WITNESS SLUSARCHUK:

A Geothermal analysis and terms that we refer to it involve measuring, analysing and predicting the temperatures in the ground and the possible changes that these temperatures may undergo as a result of the construction of the pipeline and the ancilliary facilities.

Q Now, Dr. Clark, were the portions of this application or the pipeline dealing with a geotechnical aspects prepared under your supervision?

WITNESS CLARK:

A Yes, sir, by geotechnical personnel. Several geotechnical studies have been completed by the geotechnical group and their consultants. In our view this demonstrates the feasibility of the pipeline. WE are continuing geotechnical

studies in order to optimize the design techniques that are now available.

Q Could you explain what you mean by optimizing the design techniques?

A Well, briefly we feel that we are now capable of designing the pipeline for virtually every situation that might be encountered from the geotechnical point of view. In many cases we feel that these current designs are over conservative and thus fairly costly. During the next couple of years we expect that our ongoing work will result in a more optimum -- a better design, a design that would be more economical, and not a case of overkill.

Q And is that what you mean by "over conservative"? A word that Mr. Scott might misunderstand?

A Yes, they are very, very conservative, some of the designs that are now proposed and I think that we will probably deal in more detail with these aspects later on in this testimony.

Q Sir, could you discuss the special considerations of the proposed pipeline which affect this pipeline here in the north from the geotechnical point of view?

A Well, the special geotechnical features of the proposed pipeline relate to the extensive length that will pass through permafrost terrain and the operation of a

system of temperatures below 32 degrees Farenheit. The first is not unique, however, because some gas pipelineshave been constructed through small patches of permafrost located in the Yukon and the Northwest Territories as well as in the Northern portion of Alberta and --

Q Can I ask you which those ask you which those are?

A I am thinking particularly of the Pointed Mountain Line, the Westcoast Transmission

Q Where does that go? From where to where?

A Dr. Hardy could perhaps pinpoint that a little more closely because I believe he has --

WITNESS HARDY:

A Yes, it runs -- well, there is no other geographical area that we can identify it by, sir.

WITNESS CLARK:

A It runs by Pointed Mountain.

WITNESS HARDY:

A --the Vernon River and simply runs to Pointed Mountain --

MR. GENEST:

Q Could you speak into the microphone, please, Dr., we cannot hear you.

A There are no settlements that identify the beginnning and

end of that line. It is an extension of the Westcoast Transmission system up into the Territories. It runs across a corner of the Yukon Territory and then on to Pointed Mountain in the Northwest Territories. I cannot give you any better description of that except that it is not very long. It is only about 30 miles long, but it is an extension up into the Territories of the Westcoast Transmission system that runs down to Vancouver and ties into the American system.

Q Are there other pipelines, you want to continue, Dr. Clark?

WITNESS CLARK:

A There are of course other pipelines operating for the past few years in permafrost terrain in the U.S.S.R. in parts of Siberia.

Q Do you know anything about them, have you been able to gain any knowledge that is of any dependable sort from the experience of the Russians in Siberia -- I mean the pipeline experience of the Russians?

A Well, we have some knowledge of their experience since there are formal exchanges of visiting scientists or engineers and members of the Canadian Gas Arctic have visited Russia with the view to touring their pipeline facilities and even you now, I think it is later on this week, a group of twelve Russian scientists visiting our offices and our test facilities in Calgary.

They have shown particular interest in our frost heave work. Also, I believe it is three members of this panel -- Dr. Slusarchuk, Dr. Hardy and Dr. Morgenstern, were at the last International Permafrost Conference in Yakutskt and they took advantage of that opportunity to explore some areas of mutual concern with pipeline engineers that they met and I believe Dr. Morgenstern did arrange a meeting there that was attended by these three plus others to discuss some of these. I think in general we have not picked up a great deal of information. It tends to be somewhat of a one way -- we seem to offer more than we get back. I think that is because there is a wider separation with -- between the technical people there and the people attending conferences or going on international tours, whereas here our people at the working level are involved in the technical conferences and implementation of design as well as development.

Q Do you have anything to add to that, Dr. Morgenstern?

WITNESS MORGENSTERN: We did learn that the Russians seemed to be very interested in our control of temperature capability on a large gas pipeline. They seemed envious of that technology. We found that certainly they had envirable construction experience, pipaing in permafrost; but by and large we were disappointed in the amount of analysis and design and certainly environmental considerations, seepage and erosion control, drainage, that they implemented. They seemed to be post construction in their attitude and not pre-construction in the sense of anticipating problems.

THE COMMISSIONER: Just before we leave this, Mr. Genest, you said, Dr. Hardy, that Pointed Mountain was a pipeline 30 miles in length?

WITNESS HARDY: Somewhat less than 30 miles, yes.

Q Well, could Dr. Clark or Dr. Morgenstern -- these pipelines in the U.S.S.R., have they been constructed in areas of continuous permafrost, and if so, for what distance? Do you know, have you been advised of that?

WITNESS MORGENSTERN: They have long pipelines. I can't tell you how many hundreds of miles, but long pipelines in continuous permafrost, yes.

Q Is that all we know about them?

A Well, we saw some parts of them, near Yakutskt some parts were buried, some parts came out of the ground. The documentation that we were given

was pretty meager. We do know lengths, we know pressures and diameters, but detailed engineering performance has been elusive so far.

Q Well, you propose to chill the gas in this Arctic Gas pipeline?

A Yes.

Q Is it apparent to you where the Russian pipelines carrying gas are beneath the ground, in permafrost, the gas is in fact chilled ?

A They don't control the temperature, no. They -- the pipelines that we saw, any chilling would have just been natural, would pick up the temperature of the environment.

WITNESS HARDY: It should be added, I think, sir, that where --

MR. GENEST: Would you spell that for the reporters?

WITNESS HARDY: Yakutskt, Y-A-K-U-T-S-K-T.

I agree with what Dr. Morgenstern has said in his appraisal of conditions. The pipelines we saw were in the Yakutskt area and the geological conditions are quite different than any we have in Canada, and the run-off conditions are quite different. It is largely sand. They have no segregated ice. They have no problems of frost heaving.

Q I see.

A And in one stream crossing we saw, they just floated across on the water and let it freeze in the winter. They just don't have the sort of run-off problems that we have.

Q I see.

A There are other areas in Russia, of course, further north and west of Yakutskt where the conditions are more comparable to our conditions in the Canadian north, and quite different from what we saw in Yakutskt. But I saw nothing that would lead you to believe that their technology was far advanced as compared to ours. Up to a point they were very co-operative in discussing their components, and they're as anxious to learn as we were. The main barrier was language.

Q Dr. Clark, I've been asking you about the special features of the special considerations that affect this pipeline as opposed to others from a geotechnical point of view and I think I interrupted you.

WITNESS CLARK: A Yes sir. Well on this project one of the most important geotechnical considerations is the original temperature of the ground and the effect that the activities associated with construction and operation of a pipeline and the ancillary structures will have on these temperatures, and the consequent behaviour of the soil. A change in temperature, for instance, may cause soils which were originally frozen, to thaw, and other soils which were unfrozen to freeze. Now most soils, when they change from the frozen to the thawed stage -- or from the unfrozen to the frozen state, their strength, settlement and permeability charac teristics also change and these are characteristics that are of great

importance to us and their property changes must be taken into account in design.

Q When you say "their settlement characteristics change" --

A Yes, for instance in ice-rich soil, when it thaws it will settle and it will squeeze out water. That's compressability, really, is a property, a soil mechanics property; the strength, I think, is fairly apparent because frozen soil will normally have greater strength than an unfrozen soil.

Q And permeability is --

A Yes --

Q -- the ability to conduct water?

A -- that's right.

Q And if that changes, what happens?

A It affects the properties and the behaviour of the soil. For instance, when a soil that is thawed then freezes, the permeability is substantially reduced.

Q So that water can't percolate through that ground?

A Yes, at much lower rates.

We have obtained original ground temperatures from more than 100 locations along the pipeline route, and in order to predict the

effects of construction and operation on the ground thermal regime, a computer --

Q I'm sorry to keep interrupting you, the "ground thermal regime" is what? That's not a political regime, I take it?

A That's the behaviour of the ground temperatures, the changes in ground temperatures that might follow a change in surface conditions and so on, and in order to predict this, computer programs have either been developed or licenced for use. Now the results of these geothermalstudies using computer programs, are then used in the geotechnical considerations of river crossings, slope stability analysis, drainage and erosion control, pipe buoyancy and frost heaving, right-of-way behaviour,in essence, all of the work having to do with frozen soil.

Q Perhaps you could explain, or someone could explain how a computer program can help you arrive at these -- what you're trying to arrive at, I think, is a prediction of behaviour.

A Yes. In order to design we must be able to predict, and again Dr. Slusarchuk has been working very closely in this area, and --

Q Will you explain in a few two-syllable words, Dr. Slusarchuk, how this works?

WITNESS SLUSARCHUK: Mainly as a result of our geothermal computer programs to assist us in predicting the temperatures in the ground and particularly to determine the position of the

freezing or the thawing front. Once you can determine that, you then make use of that information in your standard soils work in order to design things such as river crossings, slope stability, drainage and erosion, and so on.

Q What goes into the computer?

A The input to the computer -- the various perameters such as the thermal properties of the ground, the air temperature, the -- if we are looking at a right-of-way cross-section for example, we put in a pipe and the pipe temperature, in other words we model thermally on a computer exactly what we are proposing to build and do in the field.

Q And these, if you didn't have a computer, would have to be worked out by formulas, I take it.

A Yes, that's right, and some of the problems are a little more complicated than the mathematicians have been able to work out solutions for us, so we make use of the computer in order to come up with these answers.

Q Well then back to you, Dr. Clark. I was talking abou t special considerations.

WITNESS CLARK: Yes sir. Well, another area that requires special considerations is the river crossings because of the presence of permafrost in the banks and the valley slopes. Now in the rivers, however, the water which is above freezing, precludes the formation of permafrost directly

under the beds of the larger rivers, even along the Arctic coast.

Q Can I stop you again there? You say they require -- what does the presence of permafrost in the river banks and valley slopes present, what special problems do you have?

A Well, we must be able to predict what we are doing would bring about a change in the permafrost condition, that might cause existing permafrost to melt, in that circumstance we must be able to assess the stability of that slope in the unfrozen condition. It's a special consideration because it differs in this respect from the many hundreds of river crossings that have been constructed in more temperate regions.

Q And we're going to deal later on in your evidence with how we attack those problems.

A Yes, we will be dealing with that in some detail. Another common feature of rivers of the north, particularly along the Arctic coast, is the occurrence of icings. These consist of thick deposits of ice which are caused by water under pressure being blocked by freezing, forcing itself up to the surface to the river and this again is a special consideration not encountered in rivers in more temperate regions.

Now since the Mackenzie River itself flows in a northerly direction, the ice breakup in the upstream reaches will precede the breakup in the

northern region by several weeks. As a result, major ice jams can occur during spring breakup. This results in a temporary increase in upstream water level and introduces a possibility of river bed scour.

Q Let's just stop there for a minute, Dr. Clark, because these so-called scours when I first encountered it, caused problems with me. We talked about scour and ice scour and ice gouging, could you explain what these phenomena are, how they are caused, very briefly?

A Well, scour used in this sense is the deepening of the river bed by the flow of water, and it's associated with an ice jam for instance, a dam is created, the head of water is increased resulting in a greater velocity of flow under the ice jam, and it has a higher potential to pick up and carry river bed materials.

Q What scours the bed, is that ice?

A That is scour. Ice scouring, we generally refer to as ice gouging, but at a later stage Dr. Hollingshead will be presenting more detail on this, and perhaps illustrating it. It might be a little clearer with slides.

Q But just to satisfy me, when you speak of ice scour, we are talking about the action of the water which is forced down into the stream bed, it's not the gouging by the ice itself.

A No, the gouging by the ice itself is something different. This occurs along

banks and so on and in shallow reaches that can gouge. All of these aspects of river crossing have been considered for river crossing design, have been considered for the major crossings.

Now with respect to slopes, again this is an area of major consideration. The steeper slopes along the route are located primarily at approaches to river crossings. Along the rest of the route about 95% of the terrain is flat to gently undulating with slopes less than three degrees. In general, the experience in the north has shown that slopes of less than three degrees are stable, irrespective of the existing soil conditions.

Q By "stable" you mean they don't move, they don't slide?

A They show no signs of what we would call slope failure. However, special considerations must be given to the stability of ice risk permafrost slopes which may thaw or may creep in the frozen condition.

Q Now is that true of slopes even less than three degrees?

A No sir, it would be over.

Q Over three degrees.

A Where they would require special consideration. Another area of some concern, even though only a relatively short section of the route, and that is on the eastern flanks of the Richardson Mountain, is in an area of moderate potential for seismic activity. The effects of such activity on the

stability of slopes has been considered. Now where slopes are on or adjacent to the right-of-way are considered to be marginally stable, and where slope failure may in the future effect the stability of the pipeline or cause some unacceptable erosion, it will be necessary just to stabilize these slopes, or in cases where there's some question, to monitor and to determine if the slope does in fact require stabilization.

Q And you shall be dealing later on, sir, with the techniques that you have for --

A Yes, we'll be illustrating our slope stability program and some of the stabilization techniques.

Q Then would you go on with the special considerations?

A Well, a consideration which is not unique, of course, because it applies to all gas pipelines, and that is the average specific gravity of the pipe is less than that of water.
So there is a tendency for the pipe to float due to buoyant forces. In areas where there is a potential for buoyancy such as at river crossings or across active flood plains, it's necessary to restrain the pipe, using the usual technique provided by weight around the pipe, by anchoring the pipe in the ground, by burying the pipe deeper so there is more soil above the pipe to adequately weigh it down.

Now in the continuous permafrost

zone, buoyancy may be controlled as well by flooding the ditch, and by this I mean controlled flooding, in the winter to prevent the thaw from advancing to below the pipe during the summer period when it's not in operation. That is the first summer following construction.

Q Let me see if I follow that. You're going to control the floating of the pipe by flooding the ditch.

A Yes, it would be flooded at such a rate that it would not be buoyant. In other words, a portion of the ditch would be filled, it would be allowed to freeze, and then if necessary, more of the ditch would be filled. This imparts a higher latent heat to it, it prevents the thaw front from going below the pipe, and it also creates an add freeze between the ice and pipe to hold it down in place.

Q So it stays frozen, in other words?

A It stays frozen, yes,

Q You then get the floating effect.

A Yes, and you don't get rapid infiltration with water then. You put the water in at the rate that you want to put it in, and let it freeze.

MR. GENEST: Sir, was it your intention t o have a break today, or to go right through till five?

THE COMMISSIONER: Yes, we'll

take a break now, if you wish.

MR. GENEST: This is a good place for it, sir.

THE COMMISSIONER: We'll adjourn for ten minutes.

(PROCEEDINGS ADJOURNED FOR TEN MINUTES)

(PROCEEDINGS RESUMED PURSUANT TO ADJOURNMENT)

MR. GENEST: Dr. Clark, just before the break you'd finished with the problems -- or at least your description of the special consideration relating to pipe buoyancy. Would you move on to --

A Yes sir.

Q -- other areas?

A A further geotechnical consideration is frost heaving, which arises because the pipeline is to be operated at temperatures below 32 degrees Fahrenheit. Pipeline from the Arctic coast to about the 60th Parallel is operated throughout the year below freezing temperatures, so that when the pipeline passes through unfrozen ground, the potential for frost heaving exists.

Q We had a little bit of that in the overview, Dr. Clark, but it might help others, as it would help me certainly, if you just went over, what is the problem of frost heaving in general as it affects a pipeline?

A Well, from the Arctic coast and along -- let me deal first with the continuous zone. In the continuous zone there are small

localized areas of unfrozen ground. The pipeline is carrying gas at temperatures below the freezing point of water, and this causes the ground around it to freeze. Wherever this happens, the potential exists. The severity or the amount of frost heave that may occur depends upon several factors, one of the most significant is the soil type, and others the availability of water. Dr. Slusarchuk later will be dealing in considerable more detail with the work that has gone into assessing this potential problem, and some of the design solutions that are available.

Q The consideration then, as I understand you, is the pipeline might be moved.

A Yes sir.

Q By a movement of the soil caused by frost.

A Yes sir.

Q Do I understand that correctly?

A That's right, and it's the stresses in the pipeline associated with that movement that are primarily of concern.

Q Right, Would you proceed, please, doctor?

A Yes, as I was saying, in the continuous permafrost zone there are only minor isolated areas of unfrozen ground such as the river crossings, but in the discontinuous permafrost zone, the unfrozen areas are present along the right-of-way as well as at river crossings. Now the extent of

these unfrozen areas increases as one progresses in a southerly direction, so that a considerable amount of the unfrozen soil exists near the 60th Parallel. Now in these areas, if the amount of differential heave and this is of concern, this is what imparts the stress, it's the differential, not the total heave, there has to be a differential heave to impart stress to the pipe.

Q If you have a piece of pipe in one piece of ground that stays where it is, and another piece of ground starts to push the pipe up, then that imparts a stress to the pipeline.

A Yes sir. Now if we determine that this has a potential to be excessive, preventative measures will be designed into the system. Now these measures may consist of surcharging the ground surface, for example, or replacing frost-susceptible soil with non-frost-susceptible soil.

Q Just hold on a minute, doctor, what is "surcharging the ground surface"? To lawyers that means something entirely different, I'm sure, than it means to engineers. That's a no-no, a surcharge.

A Well, it's -- in engineering it's a very useful technique in several aspects of engineering. What we are doing is placing a greater load on the pipe. Our studies have found, as Dr. Slusarchuk will show later, that the rate of frost heaving is substantially reduced as the load at the freezing front -- that is the bottom of the frost zone

as that increases, the rate of heaving decreases substantially.

Q So surcharging is putting more stuff on top of the pipe?

A Yes sir.

Q All right.

A Now other techniques, as I mentioned, in order to have the formation of ice lenses, it must have water so another technique would be to inhibit or restrict the water from migrating through unfrozen soils. These are techniques, of course, that are used commonly in the seasonal frost problem as well, this technique of inhibiting ground water flow.

Another method, of course, is to reduce the heat flux away from the frost front so that the amount of water that can be frozen there is minimized, and Dr. Slusarchuk will provide details on all these aspects later.

Q Will you tell us what the heat flux is?

A Yes sir.

Q Tell us now.

A I don't want to detract from what he might want to say, but the heat flux is actually the flow of heat through any given area. If that clears it?

Q Not really. Well now how are geotechnical considerations affected by environmental concerns?

Now the environmental and geotechnical groups at Northern Engineering were merged in March of 1974 and they have been operating under my direction. There is a considerable inter-relationship between biologist, plantecologists and engineers in matters of mutual concern. Environmental consultants and staff biologists have participated in route location, feasibility studies, and special studies relating to specific engineering requirements. A major segment of the environmental program that has been carried out to date has been a collection of baseline data which provide a better understanding of the eco-systems along the route and form much of the basis for addressing environmental concerns in final design and in assessing impact.

Now examples of inter-disciplinary studies include the assessment of borrow areas and rehabilitation schemes, as outlined in our report, pipeline related borrow studies of March'74, also the development of preliminary designs of river crossings as described in our report on preliminary design of river crossings of July, 1974 and December 1974, and one of the reports that you filed this morning is an inter-disciplinary study of the borrow pit operations along the Aleyeska Pipeline route carried out by a geotechnical engineer and a fish biologist.

The development of drainage and erosion control measures, as they appear in the alignment sheets, and are described in the application is another example of inter-disciplinary approach to design.

Several meetings between design engineers and environmental consultants have been held on this subject of draining and erosion control.

Q This drainage and erosion control, is that -- does that have just an impact on the integrity of the pipeline, or does it also have other consequences?

A There are other consequences. I think the development, design of drainage and erosion control measures is of considerable importance to the pipeline owners since the integrity could be affected, but it is also important to prevent siltation occurring in rivers or denuding of certain areas if the measures are not properly designed and implemented.

Now, another example of our engineering and environmental interrelationship which provides means of identifying environmental concerns is interdisciplinary field reconnaissance of the route and the ancilliary sites. Several of these have been made in Alaska and Canada and more will be made as required for final design.

Q Interdisciplinary means that you have more than one kind of expert going along on a trip?

A Yes, sir --

Q Right --

A For example, we have recenty had a -- or late last summer we had a reconnaissance of Alaskan portions of Canada where we had a wild life biologist, a fisheries biologist, an ornithologist, civil engineers, geotechnical engineers and so on.

Q Will you require more of these for the final design stage of the --

A Yes, we would expect to be looking particularly at such things as

borrow pits. The environmental consultants have looked at our strip maps and at the development plans that we have illustrated in our report and they have advised us now to some extent on the sensitivity of these and this will require further field reconnaissance to confirm what the potental for environmental concerns is at those areas.

Q Now, couldyou -- I would like to move on now to the subject of the studies in your field of expertise that were undertaken by Arctic Gas or by your organization for Arctic Gas.

A Well, we can perhaps for convenience classify the studies into three separate groups, each of which includes several functions.

These are, number one, the field studies and these studies have concerned themselves with terrain and geological reconnaissance, the test drilling and the hydrological and river engineering studies.

The second would be office studies, again, which concerns itself with terrain studies, the geothermal studies, the hydrological and river engineering studies and studies of special terrain problems.

The third grouping would be the test site studies, and these include meteorological studies, geothermal studies and again special terrain problem studies.

Q And these are all described in what we filed at the beginning of your evidence as an exhibit that was Appendix "B" to the summary of your evidence?

A Yes, sir, they were.

Q I would like to move to the test sites, Dr. Clark. Would you pelase describe the test sites that were established to gather geotechnical data.

A Yes, sir, pipeline research facilities had been constructed and operated in three locations in the northern regions of Canada, in Alaska, in order to gather the data and gain experience which would assist us in the design of a reliable, safe and environmentally sound pipeline system. The location selected for these studies were Prudhoe Bay in Alaska, Sans Sault Rapids and Norman Wells in the Northwest Territories. The test sites were carefully selected to provide permafrost and terrain conditions which were representative of considerable lengths of the proposed route. This realized that the pipeline would encounter terrain units and conditions different from those that could be selected at any given site. The site conditions selected tended towards the more difficult end of the possible range.

Now, since it was not possible to gather data on the complete range of geothermal and meteorological conditions along the proposed route at the test facilities, a large number of remote

ground temperature measurement sites were established along the right-of-way.

Q Just about how many -- can we name that number?

A There was over a hundred, sir, I think that it is about 115.

Q Right --

A Now, a fourth test facility was built and it is currently under operation in Calgary, Alberta, in order to study the frost effects caused by operating a buried, chilled gas pipeline in unfrozen, frost susceptible soil.

Q Mr. Williams, I believe that you were the -- in charge of the Sans Sault project, test facility?

WITNESS WILLIAMS:

A Yes, sir.

Q What was your function in regard to that?

A I was a resident engineer on the construction of the San Sault facility, looking after the interests of the Northwest Project at that time. The site itself was constructed by Banister Construction under our general supervision.

Q I wonder, sir, if we could have the benefit, I understand you have got a little slide show for us to illustrate that facility, what it comprised, how it was constructed and so on.

A Yes, sir.

Q And I wonder, Mr. Commissioner, if I might ask the witness to give a presentation on that site.

A Mr. Commissioner, before looking at a few slides that show what was constructed at Sans Sault, I would like to first briefly outline why the test facility was constructed, the criteria or requirements of a suitable test site and how this particular site was selected.

We constructed the test facility because we wished to verify the chilled gas concept to show that with reasonable construction care and disturbance restoration, natural gas pipelines-- to show that with reasonable construction care and disturbance restoration, natural gas pipelines can be constructed and operated safely in permafrost conditions without adverse affect to the environment. We wished to provide a means of field verification, of computer programs designed to predict changes in flowing gas temperatures and soil temperatures around the pipeline. We wished to provide a means of studying methods of restoring the backfill and right-of-way after disturbance by pipeline construction.

We wanted to study the problems that might be encountered between the time of construction and the time of operation when the chilled gas starts flowing in the pipeline. We wanted to better understand northern construction problems, including weather, transportation, logistics,

communications, et cetera.

The criteria that we used in selecting the site were: it must be located in the permafrost region, perferably the discontinuous zone where high ice content soils could be most difficult. The site should have a diversity of soil and ice content conditions within a small area. It should be near the Mackenzie River which provides a means of transportation for heavy construction equipment and is representative of the conditions through which a large portion of the actual pipeline will be located. The site should be near a source of gravel for road and facility/pad construction.

And the methods we used in selecting the location were: through route reconnaissance by aircraft and the study of aerial photography by Dr. Mollard and others, five potential sites were selected. A soils drilling investigation program was conducted in June 1970 on the site considered to have the most potential and as conditions were found to be satisfactory, the search was discontinued.

The Sans Sault Test Site is located on the west side of the Mackenzie River between Norman Wells and Fort Good Hope about 70 miles south of the Arctic Circle. It is near the confluence of the Mountain and Mackenzie Rivers and near Sans Sault Rapids.

Now, could we have the first slide, please.

This first slide was taken

in late March of 1970 on a reconnaissance trip to inspect the potential site. The Mackenzie River along here, the Mountain River coming in, in here, this is known as East Mountain. There are several thermokarst ponds and lakes in the area, a couple of seismic cuts that were one to two years old and a winter trail down here that was 15 years old.

The next one please.

This is the same area looking in the other direction. The Mackenzie, the Mountain River, more seismic cuts, thermokarst ponds and the Sans Sault Rapids are over about in this area. And this gives an idea of the winter vegetation at the site, very sparsely populated black spruce, some of these small trees only a couple of inches in diameter could -- can be up to a hundred years old. Here again the Mackenzie River and East Mountain.

Next, please.

And this is another view of the same area after construction and I would like to first briefly outline what was constructed and then we will go back and see a few slides of how it was constructed.

Again, the Mackenzie River, East Mountain, the fuel storage facilities. This is the camp area, living quarters, our utility building, this is one of the seismic cuts that you saw in the previous picture. This is more fuel storage here and this is our equipment area, the power generation equipment, the refrigeration equipment, the compressors

in the middle here. This is the cycling circuit -- we will get into a bit of detail of that in a minute and I am going off the picute,in this area is what we call the cold circuit and there are gravèl roads of course around the two circuits.

This is a view of the compression equipment, the compressors to circulate the air to the cycling circuit, and in this other building the compressors for the cold circuit and the lube oil console council in between. Next, please.

This is the back of the compressor station that we just saw. This is the line running out -- I'm sorry, the far one, this was the line running out to the cycling circuit, and the line on this side is the return line, so the air coming from the compressors comes to a "Y" branch here, and can go through the chiller or the heater. This is a refrigeration unit that cycles chilled freon to the chiller for cooling the air, and there is a heater built in that cycles hot glycol through the heater for warming it. These were usually used in combination to give us a little better control. Next, please.

So this is then the circulating -- I'm sorry, the cycling circuit, the chilled air from the compressors that we saw comes along this elevated 16-inch insulated line to a buried section of 48-inch pipeline along here, through some more elevated 16-inch connecting lines, and about 500 feet of elevated 48-inch pipe here, and back into the 16-inch insulated line to the Compressor Building. Now we call this the cycling circuit because periodically the temperature in this buried section of 48-inch line was raised to a temperature above 32 degrees Fahrenheit. Normally it operated at 25 degrees

Fahrenheit, but periodically we took it up to 44 degrees Fahrenheit, and of course, when the temperature gets above freezing, thawing begins and with a gas pipeline with the thawing and the generation of free water, the pipe would start to float. So we installed this hold-down housing over the pipe, and I'll get to that in a minute. The elevated section was installed just to determine what problems might be encountered if that mode of construction became necessary. In our present plans,we do not plan any construction in this elevated mode except for a few sections near the compressor station.

This, of course, is the living quarters, the sewage disposal plant, this line along here was excavated for the -- during a ditching test and no pipe was put in the ditch, and so the spoil material that was returned to the ditch line, it thawed and caused a compression -- I'm sorry, a depression, that probably wouldn't have happened if 48-inch pipe had been in the ditch. This little thaw area, we stripped some vegetation off for our research program, and the thermokarst started developing and then we filled it with wood chips -- you can see the beginning of the wood chip installation here. We filled the whole area with wood chips and pretty well slowed down the development.

O.K., we'll just get back to the hold-down arrangement over the buried 48-inch pipe, please. This is a diagramatric view of the hold-down arrangement, the 48-inch pipe buried with

about three feet of cover over natural ground level. We installed piles here that go down much deeper than this diagram indicates, on each side of the line, with a cross-beam structure over-head, and a saddle over the pipeline connected to a centre column, to control the floatation. Next picture, please.

This is a picture then of the arrangement, one of the piles. The other one is out of view here. The centre column holding the pipe down and these steel blocks here, they were just tack-welded together and when we wanted to conduct a cycling test, we knocked one of these blocks out and allowed the pipe to float to the extent of the thickness of the steel block, and there were four of these arrangements on the pipeline. I might mention that when the temperature was raised to 44 degrees in the summertime, we got floatation within a matter of three to four hours. In the wintertime, of course, that was a little bit slower. Next picture, please.

This is the cold loop, the cold circuit where there were three 500-foot sections of 48-inch pipe buried in this configuration. We followed -- I'm sorry, again inter-connected with 16-inch insulated lines. The temperature of each one of these buried sections was controlled in dependently -- Section No. 2, of course, was controlled with refrigeration and heating equipment at the main facility. This one was controlled by the heating and chilling facilities here, and more heating and chilling facilities here. During the first year of

operation, the operating temperature to this section was 28 degrees Fahrenheit, Section 3 was 25 degrees Fahrenheit, and Section 3 was 22. The second year of operations, we changed that to 9 degrees Fahrenheit, 7 degrees Fahrenheit, and 5 degrees Fahrenheit. The reason for changing the temperature was partly to determine the effect of the lower temperatures on vegetation, and partly to induce more severe stresses into the buried pipeline. I should mention here that the ditch flooding that Dr. Clark referred to was done on these three sections. We partially -- we dug the ditch, installed the pipe, backfilled the pipe to about the top of the pipe, and then hauled water from the Mackenzie and put it in the ditch. The main reason we did it here was because, if during the summer the pipe floated, well then the test would be all over, end of report; so we wanted to make sure that it stayed in the ground, and we found this method of ditch-flooding very successful.

The soil conditions in these three sections in this area, there is an anomaly here of very deep organic material, as much as eight or nine feet deep, with ice content up to 90% by weight. This section had two to three feet of organic cover over siltic clays, with ice contents in the 30 to 40% by weight, and the third section, particularly near the top of the knoll, was in a silty sand condition with ice contents in the 10 to 20% range. There's a buried section on the cycling circuit that's out of the picture here, they were fairly high, too, in the

-- oh, 30 to 40% range. Next picture, please.

This is just another view of the cold circuit, the cycling circuit. You notice the slight difference in elevation here. This general area on the top of the knoll in the silty sand condition with lower ice content than the material in the -- below the hill. This clearing along here was to do a snow road construction research project. The right-of-way was cleared by hand, and we tried to -- if any of you have been there, you'll notice that the terrain is very hummocky and we'll talk about that later. The test here was not too successful because we didn't have the proper equipment at the time. Of course we've done more research since at Inuvik and have found methods that we feel we can construct an adequate snow road but anyway, many passes of equipment were made over this section, and very little damage was done to the right-of-way. Next, please.

This is again a cross-section, diagramatic cross-section of the pipeline to illustrate where the 48-inch line here, to illustrate where the temperature readings were taken. Each dot here represents one temperature censor above the pipe, at the side of the pipe, below the pipe, again farther out to the side, and a reference string out farther. The temperature dials were installed in plastic pipe so as to keep them in position with windows cut in to get a true reading. Each one of the buried sections had four rays of temperature censors like this, making a total of about 550 temperature point readings in

the system. Each diode point was connected by wire back to the control room, and the temperature could be called up at any time and get a print-out of the whole set of readings on a teletype print-out. Next, please.

O.K., that's briefly what was built. Now let's look at a few slides as to how it was built. This picture was taken in about late August of 1971, construction had started. You see the gravel roads here, the heavy equipment was brought in by barge on the Mackenzie River, the temporary camp facilities in this area and the gravel for the roads and the facility pads were taken from the shore-line of the Mackenzie River along here. Next picture, please.

This was taken about the same time showing the extent of construction in August, the road coming up from the river that we saw previously, the fuel facilities, this is the gravel pad for the living quarters, the main equipment facility pad, the rights-of-way here were cleared by hand and the brush was laid in the middle of the clearing and the gravel in dumped by truck onto the brush.

The only work that was done in the summertime of course was what could be done on graveled surfaces, no pipeline construction took place in the summertime.

Next please.

MR. GENEST: Before you leave that one there is that long water ditch there. What is that?

A Yes, sir, that -- Mr. Genest, that is one of the seismic cuts that we saw earilier. It was probably done a t a time before the new landuse regulations came into effect and the vegetation cover was stripped off and you can see that some thermal degradation is taking place along the cut.

Q It was badly done then--

A Those are your words, sir.

Q I cannot give evidence, at least not yet. What do you say?

A More care could have been taken, certainly.

Q Right --

A Next please. This is another shot of the same area at the same time. We have a drilling rig here for installing piles. You can see that some of the piles have been installed in this area. The pile installation was done by means of drilling a hole a little bit larger than the steel pipe that we use for piles. The steel pipe pile was installed in the hole and the angle is between the outside of the steel pile and the wall of the hole was filled with a water mineral soil slurry and was allowed to freeze in.

The next picture please. This shows one of the drilling rigs that we used, it is an auger type drill. This particular one is mounted on a soft track low ground pressure bearing vehicle. Next please.

In the wintertime, this is the same drill rig in the wintertime. We mounted a canvas canopy over top of the drill rig and the walls of -- the canvas walls can be lowered and you can put a little heat in there so that the workmen can go on with that process at very low temperatures. This one was taken on a bright, sunny day.

Next one, please. And as we mentioned earlier, no pipeline construction work started until a frost had set in and this shows a picture of a side boom picking up a joint of

48" pipe. This particular shot is on a gravel pad.

The next one, please. However, this one is out on the right-of-way. There is no gravel pad but you can see that with the compacted snow a good protection of the vegetative cover can be achieved.

Next please. Another similar picture of the side boom picking up the joint for installation. It is a very cold day. We found that work could go on to when temperatures got down to -35 to -40, but we did experience days colder than that and most of the work on those days were restricted to what could be done in the utility building or inside. The lowest temperature I think we experienced that winter and this is in the winter of '70 - '71 was -63°F. This is the gravel road beside -- well, I think Section number 2 the ditch has been excavated. Next, please.

This just illustrates the canopy that was constructed, the canvas canopy over the welding operation. You can see the light from the welding operation. A simple cover like that allowed work to go on in very low temperatures. Next, please.

And this shows the ditching operation. IN 1971 this was one of the largest ditching machines in North America. There have been larger one s developed and constructed since this time, but certainly when this was in operation we realized that although it could ditch permafrost it

really was not adequate for a project of this magnitude so we did promote the development of larger machines.

Next please. One of the most difficult problems that we have had are the teeth that have to excavate the frozen material. They are subjected to pretty hard material and we have done a lot of research and development in the ditcher 2 area and we think that we are very close to having the problem solved now.

Next please. Another picture of the ditching machine with the material coming out on the conveyor belt. You notice that it is pretty fine, fine material. It is well suited for backfill purposes.

Next please. This is a section of the ditch showing geotechnical technicians and engineers in the ditch. They are logging the material in the ditch wall. We thought it was important to know what was in every foot of the ditch so that if problems developed along the line we could tie the problem back to the type of material in that particular area and hopefully come up with a solution.

Next please. This is a diagram showing the type of log that they came up with on one section of the ditch wall. The top layer here is organic matter. Lens of clay in here, silt, here and the black spots here are solid ice, probably remnants of ice wedges that do not come

quite to the surface.

Q Where is the pipeline --

A The bottom of the pipe, Mr. Genest is along this line in here but before.--

THE COMMISSIONER: Is that line on the level -- your pointer is wigwagging. The line is on the level I take it.

MR. GENEST: He is a bad pool player.

A It pretty well follows the slope of the terrain itself, Mr. Commissioner. Now, that the question has been brought up I might ask why -- how do we know what material is likely below the ditch line, the bottom of the ditch and before the ditch was constructed we put in a drill hole at ten foot centres down the centre of the ditch line and cored and logged the material in each drill hole so that the information showing below the bottom of the ditch is by inference rather than by ditch log observation.

Q Well, I think, Mr. Williams, the Commissioner and I are having the same trouble. What we are trying to get at -- there is a straight line in the middle of each of those diagrams. Is that the bottom of the ditch?

A Well, for instance here, Mr. Genest, the heavier line above is the bottom of the ditch. The lighter line below is a horizontal line that depicts the elevation of that at that level.

Q So the bottom of the ditch fluctuates a little bit, does it?

A Minutely. It tends to follow the topography --

Q The top of the ground?

A Yes, sir.

Q How do you get it straight and flat when you lay the pipeline down? Or is that a question I should not ask?

A Well, it certainly won't -- the bottom of the ditch will not all be flat -- but it will be fairly uniform because the right-of-way surface will be prepared with compacted snow to give a fairly even surface, not necessarily flat in the mean of horizontal, but it will be even and the ditching machine will, in most instances, dig a ditch that conforms to the surface. Now, the ditcher does have some capabilities of deepening or shallowing the ditch that it digs, but in normal construction the bottom of the ditch fairly closely follows the contour -- the surface contour and the bends that are caused by the surface contour are taken up by bending the pipe to fit the bottom of the ditch that is constructed.

Of course, in southern pipeline work a lot of grading is -- right-of-way grading is done to make this a fairly flat surface on top to work from. In the North of course we will not be -- in ice ridge permafrost conditions we will not be able to do that and so we have to do the best we

can with snow cover to make a relatively even surface so the ditch is not going up and donw like this but it certainly will hve some bends in it.

Q And then you bend the pipe to fit the bottom of the ditch?

A Yes, sir.

Q Did we cover that, Mr. Commissioner?

THE COMMISSIONER: Yes, thank you.

A This is a close up of the ditch wall showing segregated ice in one location. You can see -- this is the ground surface, so this is probably 12 to 18 inches down here and some of this ice -- at least some of this ice will be thawed in the summertime and in the part of the active layer.

Next please. This is a slide that shows some of the deep organic material that I referred to earlier, the brown is organic material and this -- the grey -- is mineral soil.

Next please. I threw this one in because probably quite a few of you have tramped around various locations in the north and found the terrain real rough and hummocky and this shows a cross-section of a hummock. They vary in diameter from 6 to 16 feet or more. Very fine material has migrated to the surface and a considerable amount of segregated ice underlying.

Next please. More segregated

ice in the ditch wall, this in a mineral soil condition.

Next please. Another section of the wall showing deep organic material. In one section the ditcher machine went through a log that was about 8 or 10 inches in diameter buried at about a depth of 8 feet and we took a piece of it and had it carbon dated and found it to be about 3,900 years old.

This is the right-of-way after construction has been completed. Notice there's a fairly substantial mound of excess material along on top of the buried 48-inch pipeline. This is the inter-connectiong 16-inch insulated line. This is the cantrough that carries the power line and signal cables for temperature censors and so forth. Next, please.

This is a similar picture, in the spring following construction. You can see that most of the excess material has thawed and subsided. In fact, we're showing a little bit of -- maybe in this area, maybe a little bit lower than the surrounding ground. Next, please.

This is the same area one year later. We'll get into the vegetation cover in a minute. But you can see that there is excess material on the sides and a slight depression along the ditch line itself. Next, please.

In this, this is section No. 3, and you can see here that there still is considerable excess material along the ditch line, and that was taken, oh, at least two years after construction. Next, please.

Not everything that we tried was completely successful. This is part of the 48-inch elevated pipeline, polyurothane foam insulation, polyethyline jacket, this is the normal procedure for a southern operation, but when the temperature got down below 40 below it cracked pretty badly. Next picture, please.

So our solution to it was to jacket the whole section with aluminum sheeting to protect the insulation in place. Next, please.

This is Section No. 1 on the cycling circuit that has the hold-down housing. This mess along the side here was where we -- before ditching, we tried to remove the vegetative cover. We were trying to get it in sheets so that we could replace it back to the ditch line, but we found that it broke up pretty badly and so we didn't return it, but our botanists tell us now that we were probably in error even though it did break up, that we should have restored it to the ditch line and probably a fair bit of it would have caught and would have grown and would encourage the growth of native vegetation . Also on this section, instead of mounding the excess material over the ditch line, we spread it over the right-of-way. This picture was taken in June of 1971, and this gentleman is broadcasting grass-seed over the area, about 18 varieties of grasses were sown at that site. Next, please.

This is in July, one month later, the grass has germinated and is coming along. Next, please.

This is in August of 1971, two months after seeding. The different colors here indicate different types of grasses that were sown, you can see some are doing better than others. Next, please.

This picture was taken in 1973, it's the same test section. You can see that the growth is fairly substantial, and some of the native materials are coming back. Next one, please.

This was taken last summer, particularly along here and in here the brush and shrubs are coming back and we don't have the large pools of water here that you can see in one of the previous pictures. Next one, please.

This indicates the height of growth of the grass at the test site, although it is fairly short yet. Next, please.

This is Section 3 and people might get pretty concerned about the water that is ponded in this area. I think this was taken about a year after construction. However, the picture was taken after heavy rains and you'll see in the next picture please, which is the same section, that that water is not permanent, it has dried up. This was taken last summer, the summer of '74. There is one pond here, but in general the -- it's fairly dry. Some of the grasses, as you can see, are not as good as some of the others.

The site -- the test site was operated, that is with chilled gas flowing through it, from March 1971 until mid-January '73, and it has not been operating with chilled gas flowing through it since January '73. Will you just back up to that last one, please, Lee? On the pipeline we had several risers on the line where we could measure, with survey equip-

ment measure the elevation of the pipeline. These risers worked down and were fastened to the pipe itself, and periodically we took survey measurements on the risers and we found that neither during the operation or the almost two years now since the -- it's more than two years now -- since the site was shut down, none of these buried sections have shown any sign of movement. I think that's about it.

MR. SCOTT: Mr. Commissioner, it might be helpful if Mr. Williams can provide to Mr. Genest either slides or photoprints from them, one that can be an exhib it and then perhaps we can ask him on some later occasion to amend his evidence by correction to show the number of the slide or photoprint to which he was referring, and in that waY the transcript will provide a full account not only of his words but of the slides to which he was referring at any given time.

MR. GENEST: I propose to do that, Mr. Scott, with every slide presentation we have. Hopefully, as time goes on we'll have them ready with the slides.

Q Mr. Clark, can I ask you then, that was the Sans Sault testsite, was that degree of information that you gathered to enable you to arrive at conclusions about the geotechnical feasibility of this pipeline, was that the most important one or were there others?

WITNESS CLARK:

A It was certainly the largest one, however, all three testsites, the pipelines

were buried in permafrost. There was no unfrozen soil under the chill line at Sans Sault or Norman Wells or Prudhoe Bay, and that led us to select the testsite in Calgary. In that particular area we were very well acquainted with soil conditions.

Q There was no what?

A No unfrozen soil at any of these testsites.

Q Yes, yes.

A so we wanted to test the pipeline then in what we judged would be one of the most severe frost-heaving situations that we could find, so we ultimately, after looking at several areas, again one of the things we were looking for was a site that would be reasonably accessible because we wanted to do a lot of experimentation at that site, we looked in the Calgary area and found a site in North-west Calgary, which is an old glacial lake basin, in a very silty and clay-silt soil with a water table that is relatively high, the pipe was buried at or below the water table, and it presented us with, we felt, a situation where the potential -- all the conditions for frost-heaving existed.

Q You also had the Prudhoe Bay facility and the Norman Wells test facility, these are described in Exhibit 54, which is Section 8 and 9 of the application. Did you or anyone in your panel have anything to do with the construction and operation of these facilities?

A None of our panel did, sir, but there were geotechnical engineers involved with both sites and geotechnical and geothermal data was developed and has been reported and made use of by our group in assessing our geo-thermal models and other geotechnical aspects

Q Then that's described in the application material?

A Yes sir, it is.

Q I don't propose to go over those in the same detail, Mr. Commissioner.

Now the test facility in Calgary, you've described the Calgary test facility, I understand that Dr. Slusarchuk is going to be going into that a little more deeply.

A Yes, he will be presenting a description of that particular testsite as well as the other programs that were developed at the same time -- the laboratory programs and a model pipeline testing program.

Q We'll come back to that. Could you describe any other intensive field studies that have been undertaken?

A Yes, we have carried out a number of field drilling programs since the project was initiated. These have been related to verification of terrain typing, in examination of specific areas such as potential river-crossing sites or formerly cleared areas for permafrost regression studies.

Q What is a regression of permafrost?

WITNESS CLARK:

A This is where the thermal regime has been changed, for instance, by removal of trees or surface vegetation, and there is a change then in the permafrost table and we've investigated a number of these; or a number have been investigated in connection with the project.

We've also made a number of studies to assess the river regime in reaches of a number of the proposed river crossings. Studies have been made of ice break-up, with particular emphasis on the Point Separation crossing. These have been repeated since 1973, and they will continue in the future. There is also an ongoing interdisciplinary study at Chick Lake which was initiated a few years ago.

MR. GENEST:

Q Where is Chick Lake?

A Chick Lake is north of Norman Wells, I believe it is about 85 miles on the east side past the Gibson Gap.

Now, our particular input into that study has been a collection of data on ground water behaviour and relating this to the overall hydrolic aspects. At this site we've made small watershed hydrolic field studies, and these will continue through design and construction phases. These studies, as well as the other environmental studies that are being carried out by our three consulting groups, as well as our plant

ecologists on our own staff, provide a baseline data, including hydrologic data in undisturbed terrain, which will be crossed by the pipeline in the Mackenzie Highway.

They also provide understanding the magnitude and distribution of surface drainage to be used in the overall design of the drainage and erosion control measures. This gives a measure of the magnitude of potential icings for example, by studying the active layer flow which might occur over an operating chilled pipeline and it will lead to effective control design measures where required.

Subsurface flow will be computed from the observation of the ground water table, the slope and the measurement of the insitu permeabilities. At this site the permafrost table will be probed to determine the thickness of the active layer through which this flow occurs.

Surface flow will also be studied, by monitoring the flow into two small creeks which drain a part of the Chick Lake Basin. These flow measurements will be related to precipitation data, with a view to improving the current available method of predicting small channel flow. The Chick Lake is not entirely a geotechnical study, our input is one aspect of an interdisciplinary study.

Q Well, these studies I take it are not completed, they are in progress at this time?

A The hydologic studies were initiated last year, they will be continued this year,

and I believe the biological studies were initiated the year before last, and some hydrology data was gathered at that time.

Q Dr. Clark, or perhaps Mr. Williams, could I ask what is the magnitude of the financial expenditure that has been made on these test sites, the Sans Sault, the Calgary, the Prudhoe Bay, and the Norman Wells, to this stage?

WITNESS WILLIAMS:

A Yes sir, I can give you a few of them in round numbers the cost of construction and operation of the test facilities to the end of 1974 were: Sans Sault, four and a half million dollars, Prudhoe Bay, two and a half million dollars, in addition $82,000 in environmental studies were conducted at the specific site at Prudhoe Bay, and Norman Wells, $918,000.

Q What about Calgary, do you have a figure on that?

WITNESS CLARK:

A To this point in time, the expenditure at the Calgary test site, which includes the laboratory testing and model testing, is of the order of $700,000, it's an ongoing study and our budget for the total study is about a million dollars, it will be continued through this year.

Q That in round numbers gives me about, between 8 and 9 million dollars? Is that correct?

WITNESS WILLIAMS: Very close

to nine millions dollars.

Q In your opinion, and perhaps I can ask this of the panel generally, how far has knowledge of the problems you have studied been advanced as a result of these test programs? Who wants to -- Dr. Hardy is the one having the longest experience span in this, what can you tell us about that?

WITNESS HARDY: Well,sir, as far as the fourth project is concerned, the one in Calgary, on the frost heaving. That,as a research program is the biggest program of its kind, that's ever been conducted in Canada. It's involved more money, involved more people, its objectives were broader than any program that's ever been conducted in Canada. It was laid out not from the point of view of simply getting restricted results, it was laid out as far as I'm concerned, after my association with research councils both in N.R.C. and Alberta research council while I was at the university. This program had just as much attention given to it, in planning and in quality of instrumentation and breadth of outlook in what was to be achieved,as any program I've ever seen designed with a view to getting grants from the Research Council. The results that Dr. Clark has mentioned definitely have made a scientific contribution irrespective of their merit as far as the design of the pipeline is concerned. The problem of course, the programs had to be sold, if you like, the owners and Cagsol had to be convinced that these expenditures were warranted. But as far as I am aware, the money was forthcoming to conduct that

particular program and I think it's also fair to say this was true of the Sans Sault Rapids test section. The money was forthcoming on the scale, or to maintain a scale of investigation that is of the highest technical quality. Now, there are not basic reseearch programs perhaps in the sense of pure research, they are applied programs, but nevertheless they were designed with, to give as complete results as you could ever expect them to give within the limitations of time.

Now, Dr. Morgenstern has had a lot of experience in this sort of thing too, and perhaps his comments, he would agree or he would not agree, or add to them.

Q Dr. Morgenstern?

WITNESS MORGENSTERN:

A Yes, I would agree with that Dr. Hardy, but I would also like to draw attention to the total set of investigations that Dr. Clark described to us, not just the intensive field studies, but going back to the other Office Studies, and Analytic Studies and Borrowing program.

This, in my experience constitutes the largest intergrated program of research and development for possibly any project, but certainly any Northern construction project in Canada, and very likely comparable if not greater than that for the Alaskan pipeline.

MR. GENEST:

Sir, my watch says five. I'm moving to a different subject, is this a convenient to break till eight o'clock, I understand?

THE COMMISSIONER: Yes, just before we adjourn, I wonder if I could ask a question. Dr. Hardy, I may have missed something, but I gather there was a group of engineers from the Government of Canada, Arctic Gas, and so forth, that went to Russia in the spring or just a month ago, or something of that sort. Am I right about that?

WITNESS HARDY:

A I'm not aware of that sir, but there may be other people that are. We were looking at, following our visit to Yakutskt, we fully anticipated that there would be exchange of visits under the auspices of government programs, and there were people in N.E.S. , and Cagsol that were all set to go over, and this turned out to be aborted. But I'm not familiar perhaps Dr. Clark can give you information on this more recent trip. I'm not familiar with it.

WITNESS CLARK:

A Yes, Mr. Commissioner, there was a trip made by Canadian scientists and engineers and government people. I don't remember the exact date, it was fairly recent. One of the staff engineers from Canadian Arctic Gas went on that trip, and spent I believe it was two weeks in the U.S.S.R. including the travel time, and they looked at gas lines and met with a number of the operating people I believe from Russia. We've had informal discussions with him since his return. He did not get to the point where he was talking with the people at the design level. It was

mostly in operations I believe that they pursued.

THE COMMISSIONER:

Yes, well you might consider bringing that gentleman along as the member of a panel Mr. Genest, at the appropriate time?

MR. GENEST:

Perhaps we could have Professor Jackson organize a community hearing in Yakutskt, sir.

MR. COMMISSIONER:

Well, I think it's time to adjourn until eight o'clock.

(PROCEEDINGS ADJOURNED UNTIL APPROXIMATELY 8 O'CLOCK)

MACKENZIE VALLEY PIPELINE INQUIRY

IN THE MATTER OF AN APPLICATION BY CANADIAN ARCTIC GAS PIPELINE LIMITED FOR A RIGHT-OF-WAY THAT MIGHT BE GRANTED ACROSS CROWN LANDS WITHIN THE YUKON TERRITORY AND THE NORTHWEST TERRITORIES FOR THE PURPOSE OF THE PROPOSED MACKENZIE VALLEY PIPELINE

and

IN THE MATTER OF THE SOCIAL, ENVIRONMENTAL AND ECONOMIC IMPACT REGIONALLY OF THE CONSTRUCTION, OPERATION AND SUBSEQUENT ABANDONMENT OF THE ABOVE PROPOSED PIPELINE

(Before the Honourable Mr.Justice Berger,Commissioner)

Yellowknife, N.W.T.

March 17, 1975.

PROCEEDINGS AT INQUIRY

VOLUME XIX - A

EVENING SESSION

ALLWEST REPORTING LTD.,
4299 CANADA WAY,
BURNABY 2, B.C.

APPEARANCES:

Mr. Ian G. Scott, Q.C. Mr. Stephen T. Goudge, Mr. Alick Ryder and Mr. Ian Roland	for Mackenzie Valley Pipeline Enquiry;
Mr. Pierre Genest, Q.C. Mr. Jack Marshall, Mr. Darryl Carter, and Mr. John Steeves	for Canadian Arctic Gas Pipeline Limited;
Mr. Reginald Gibbs Q.C. Mr. Alan Hollingworth	for Foothills Pipelines Ltd.;
Mr. Russell Anthony, Prof. Alastair Lucas & Dr. Andrew Thompson	for Canadian Arctic Resources Committee;
Mr. Glen W. Bell and Mr. Gerry Sutton	for Northwest Territories Indian Brotherhood and Metis Association of the Northwest Territories;
Mr. John U. Bayly	for Inuit Tapirisat of Canada and the Committee for Original Peoples' Entitlement;
Mr. Ron Veale and Mr. Allan Luke	for Yukon Native Brotherhood;
Mr. Carson H. Templeton	for Environment Protection Board;
Mr. David Reesor	for Northwest Territories Association of Municipalities
Mr. Murray Sigler	Northwest Territories Chamber of Commerce

I N D E X

EXHIBITS (ERRATA):

Our Exhibit 78 should be Exhibit 76

Our Exhibit 76 should be Exhibit 77

Our Exhibit 77 should be Exhibit 78

(PROCEEDINGS RESUMED PURSUANT TO ADJOURNMENT)

MR. GENEST: May I proceed, sir?

THE COMMISSIONER: Yes.

JOHN IVOR CLARK,
GARRY WOOD HOLLINGSHEAD,
EDWARD CHARLES McROBERTS,
WILLIAM ALEXANDER SLUSARCHUK,
NORBERT REUBEN MORGENSTERN,
RICHARD H. COOPER,
R.H. HARDY,
GUY LESLIE WILLIAMS, resumed:

DIRECT EXAMINATION BY MR. GENEST (CONTINUED):

Q Dr. Clark, you had finished before the dinner adjournment describing the test facilities operated by or for Arctic Gas, and I'd like to move on now to a discussion of the techniques which are available for the design of a pipeline from a geotechnical point of view. Would you give us an overview of these?

A Yes. Adequate design techniques are now available. For example, the geothermal analyses when compared with data obtained from the test sites, have confirmed that the models are able to predict the geothermal regime along the right-of-way and adjacent to the buried pipeline.

Q These models, sir, are the computer models that you were describing earlier?

A. Yes sir, that's correct.

Q They have confirmed that what they predict will actually happen?

A Yes sir. These analyses are applied to almost every aspect of geotechnical design related to the pipeline and its ancillary facilities. The study of river crossings and hydrology have established the applicability of techniques for determining the required depth of burial for scour protection, the location of sag points, bank armoury and construction techniques in relation to the heights of slopes that must be crossed, and we will be presenting in a slide show somewhat later, some of the river design techniques.

Q So that we know what to look for, I suffer from sag points which I'm sure are not the same you're describing. What is a sag point in geotechnical language?

A Well, it's more in pipeline language, sir. It's the point underneath the river where the pipeline curves up after it has crossed under the channel area and under the bank, and it then bends upwards towards the ground surface.

Q When you come to a river crossing, the pipeline must go down into the ground and go underneath the channel.

A That's right, where it makes that bend is the sag point.

Q And what about where it bends to go down?

A That is an over-bend at that point.

Q And bank armoury is again

what I may not understand.

A That is a protection of the bank against erosive attack by use of rip-rap such as gravel or boulders or gabiens, which are wire encased aggregates of gravel.

Q Would you proceed, please, Dr. Clark?

A Yes. The special terrain problems studied have established means of assessing slope stability and methods by which slopes can be stabilized if there appears to be a problem. They also provide an indication as to the types of slopes which should be avoided in route location, and as a result of careful location work, only about 5% of the entire route is located on slopes greater than 3 degrees inclination. Again later we will be having a more detailed discussion illustrated with slides of the slope stability work.

Procedures have been established for drainage and erosion control, and they've been applied to the pipeline in the preliminary design stage. These measures have received intensive scrutiny by environmentalists consulting to Northern Engineering, and they were found to be acceptable and to satisfy their concerns with respect to erosion and maintaining drainage. These designs that have been developed to this point in time will also be illustrated by slides later.

The pipe soil inter-action studies, which we discussed earlier, have established

techniques for analysis of field bends which provide assurance of soil stability. Studies related to depth of cover have provided the necessary guide-lines to determine the depth that the pipeline will be buried in specific soil conditions in geographic zones.

Q Can I just hold you up there a minute? What is an analysis of a field bend?

A That is an analysis where the forces acting on the soil at that bend are computed and they are then compared with the capability of the soil to resist those forces. If, for instance, it was found that the forces from the pipe exceeded the capability of the soil, then we would make a more gradual bend, for example, to distribute the forces over greater area, or to reduce them at any concentrated point.

THE COMMISSIONER: Can I ask Dr. Clark to go back for a moment, Mr. Genest?

Q On page 9 you said,

"For example, a geo-thermal analyses when compared with data obtained from the test sites have confirmed that the models, computer models, are able to predict the geothermal regime along the right-of-way and adjacent to the buried pipeline."

Now, are you saying that you are able to predict the geothermal regime from Prudhoe Bay to the Alberta border?

Am I reading this correctly?

A Yes, sir. Having the appropriate input perameters for each area we are of the opinion that we can predict what happens around the pipe when it is conducting gas at below 32°F. We are also of the opinion that we can predict what happens along the right-of-way with these models on ce the vegetation has been cleared and so on.

Q On page 10 you said, "Procedures for extablishing drainage and erosion control were developed and have been applied to the pipeline in the preliminary design stage. These measures have received intensive scrutiny by environmentalists and they were found to be acceptable and to satisfy their concerne with respect to erosion and maintaining drainage."

As I understand it Northern Engineering had environmentalists on its own staff. Are those the environmentalists that --

A And the consultants, sir. These would occur at informal meetings where we would be looking at a particular area and environmentalists might point out that there is substantial amount of cross-drainage in that area and would ask us how we would propose to cope with that. We would then illustrate how we would propose to cope with the preliminary designs and discuss how they would work, conduct the water either

across the peipeline in the case of surface water or where necessary through the back fill layer and when these were discussed and explored -- I cannot recall any situation where there remained any concerns.

Q Yes, and we will hear from those environmentalists in phase II, I believe.

MR. GENEST: Phase II, yes.

THE COMMISSIONER: Yes, excuse me, carry on, please, Mr. Genest.

MR. GENEST:

Q I think that I left you at field bends.

A Yes, we had discussed field bends, another design technique is the methods to prevent pipe floating under bouyant forces. These have been developed and will be applied on a mile by mile basis for particular conditions of terrain and ground water.

Design techniques and the perametric analysis for foundations have demonstrated that adequate foundations can be established for all structures along the pipeline route.

Q Are we going to have something on that later, Dr. Clark?

A We have the report and in fact one of the ones which you mentioned earlier, Mr. Genest, that is actually an updating of a report.

There was one produced last July which is listed in the documents available. The one that you now have is a newer version of that report --

Q That is the report on foundations --

A Yes, and we had not proposed to present any illustrations of that .

Q Well, would you mind if I asked you to just illustrate very briefly what you proposed to do about methods to prevent pipe floating?

A Well, there are several techniques of preventing pipe floating and many of these are conventional methods that have been applied to pipelines over the years. These would include weighting for instance. Under rivers, most rivers, we will use a continuous concrete coating.

Q That is, you coat the whole pipe with concrete?

A That is right.

Q And the weight of the concrete is enough to keep it from floating?

A Yes, and it has what we call then a negative bouyancy. This can also be accomplished by applying bolt on weights or by anchors --

Q Bolt on weights?

A Bolt on weights, concrete weights which are bolted to the pipe to

weigh it down or anchors that are drilled and cast in the ground, either or frozen or unfrozen ground there are suitable methods available. Some of these methods will be illustrated in the discussions that we will have and slide presentations on river crossings.

Q Could you carry on then.

A Yes, as a result of the geotechnical studies undertaken for the applicant, it was determined that the concept of a large-diameter buried pipeline in which gas was chilled to below 32°F is environmentally and geotechnically sound.

Q I do not know what the going out of the lights signifies -- boredom --

I would like to move now sir, to route selection and design and ask you how does geotechnical engineering assist in route selection.

A Yes, sir. KNowledge of earth materials, the earth processes and engineering principles was necessary in locating the pipeline in terrain that has the least tendency to be flooded, or to subside or to slump or to gully and wherever unstable terrain had to be crossed, design measures were developed to deal with geotechnical problems.

Unstable terrain is most common in the high ice content permafrost areas or

on sloping ground adjacent to rivers, near the ocean and in some parts of mountainous regions.

At certain localities the route must cross these types of terrain, but route location was done with a view to avoiding hazards by crossing difficult areas where the least construction damage would result.

Design measures were also developed to provide for river crossings, drainage and erosion control measures, slope stability problems and pipe bouyancy.

Q Now, we will be discussing these in more detail later on?

A Yes, sir.

Now, in the past many thousands of miles of pipeline had been constructed in NOrth America without major geotechnical input. However, the terrain conditions along the proposed Arctic Gas Pipeline route, particularly through permafrost areas, requires such input into design. The first permafrost studies in the Canadian Arctic with respect to a transportation route were carried out by R.M. Hardy in 1946. Since that time most major construction problems in the Arctic have had a substantial input from geotechnical engineering.

With respect to pipelines R.M. Hardy and Associates have been involved for some 20 years in geotechnical investigations related to pipelines dealing with such features as route selection, slope stability and design of river

crossings. The major geotechnical studies related to this pipeline, the Canadian Arctic Gas Pipeline, have been previously discussed in Appendix "B".

Q It is stated as "A" in the synopsis of evidence and I take it that that is a typographical error. We have already filed that as an exhibit.

A Yes, sir.

A Yes, sir. Now these have led to changes in route alignment to avoid marginally stable slopes or potentially unstable slopes, geologic features such as thermakarst ponds and karst features which might present future problems if not taken into consideration. It has been necessary to carry out hydrological studies to determine the pipe configuration at river crossings, and to predict overland runoff flow which will govern the final design of drainage and erosion control measures.

Q What is the pipe configuration at river crossings, is that the overbend and the sag?

A The overbend and the sag bends, yes. The geotechnical aspects of determining the most suitable foundation for structures is a well-established engineering function and has been applied to all appropriate structures to be built in connection with the pipeline.

Q When you speak of structures here, Dr. Clark, are we addressing ourselves mainly to compressor stations?

A Yes, that would include all buildings, communication towers, and so on,

Q Now, I take it the final design of the pipeline with respect -- at least from a geotechnical point of view has not yet been completed?

A On a mile by mile basis the final design has not taken place. The terrain typing

has been completed along the prime route; slope angles have been superimposed on work sheets; the route locations and some aspects of preliminary design are shown on the alignment sheets. The route will be refined as a part of final design. The control points, for example, such as river crossings, will first be confirmed and then the connecting overland links will be re-examined and refined. Some preliminary typical site specific designs for river crossings have been proposed. Studies previously describ ed, the field programs and the test sites have established the feasibility of the design and have provided many of the design techniques and criteria necessary for the final design activities. I am satisfied that a final design giving full account to geotechnical considerations can be accomplished.

THE COMMISSIONER: May I stop you again, Dr. Clark?

Q You say you're satisfied that a final design can be accomplished, that is on the prime route. Is that what you're speaking of?

A Yes sir, the prime route and the alternatives either filed or under consideration.

Q Now you mean the interior route through Old Crow Flats and you mean the cross-delta route as well, is that right?

A Yes sir.

Our main emphasis to this time has been placed on establishing performance

criteria rather than design criteria. For example, it's impossible to establish a single criteria in such as terrain typing as a basis for route location. Terrain is one of many considerations that goes into selecting the route. Other considerations include environmental concerns. In many instances we have moved the route to avoid an environmentally sensitive area, and by so doing have traversed less favorable ground than would have been selected solely on the basis of terrain. Now if the pipeline can be built across the less favorable terrain without introducing hazards, as is the case for the route now shown on the alignment sheets, then the less favorable terrain is accepted as preferable to the terrain which might be more environmentally sensitive. This is not always the case, however. If a move to a less environmentally sensitive area would result in a hazardous situation, the line was not moved.

MR. GRENEST: Q When you say "a hazardous situation" here, do you mean to the pipeline itself?

A To the pipeline and the terrain.

Q Right.

A Other constraints in routing include the existing facilities such as the Mackenzie Valley Highway and socio-economic concerns. If, for example, we were forced to move the line due to any other consideration, our job is to develop a

design which would be safe and environmentally acceptable. Now with respect to frost heave, deeper formation bends or settlement, the allowable movement is based on limiting deformation in the pipe. For example the stresses and strains in a pipe resulting from internal pressure, temperature differential and so on, are computed. The difference between these stresses and strains and the maximum allowable values, then represents the amount of additional stress and strain the pipe can tolerate from differential movement. These are translated into allowable deformation which establishes the performance criteria for different geotechnical considerations. The geotechnical objective is to ensure that the performance is within the allowable bounds.

Q Dr. Clark, do you mind if I take you over that one again? I am using myself as a litmus paper here. You said that deformation at bends or settlement or frost heave, what you do is you compute what is the allowable movement?

A The stress analysis people first of all, compute the stresses and strains that will exist if there were no geotechnical consideration, for example. The code establishes what is the maximum allowable, the difference between what is computed and on the basis of lay-in temperature and operating pressure, for instance, and the maximum allowable, is the stress that we can absorb from such things as heave or settlement or deformation.

Q I think I follow. What has been the geotechnical input, the input of your particular science, into environmental meetings or the concerns expressed by environmentalists?

A Well, as previously mentioned, there has been a number of informal meetings with environmental consultants and continuous interfacing with staff biologists and the environmental group at N.E.S. Now more formal meetings were held with a larger group of environmentalists in April of 73 and this was discussed by the first panel. Geotechnical personnel were at these meetings, which were primarily concerned with route location, and they participated in the reviews and revisions which were discussed at, and following the meetings; where the line was moved for any reason, again we were charged with the responsibility of developing designs.

Q What additional geotechnical work remains to be done prior to final design and construction?

A Well, additional work is required in a number of areas. For example, geotechnical assessment is required for verification of river crossing locations. At this time we are satisfied with the location of most crossings. Of the 200-plus crossings in Canada, there are approximately eight where we feel changes may be made. Now these changes will generally lie within a few hundred feet of the existing alignment. The Great Bear River

crossing is an exception in that we are currently examining a stretch of over a mile for possible re-alignment. The present crossing has been drilled at this time and its been instrumented in order that we can be sure of the integrity of the slope before it is constructed.

Q What if it lacks that integrity, what plans do you have?

A Well, we already have a design to ensure the stability of the slope, and this was shown with the application. We have made a parametric analysis of this design and found that within the range of expected parameters that it would be safe. Ultimately it would be a case of determining whether it was more economical to implement this design or to move it to a place where perhaps stabilization would not be required.

Q Well, do I understand correctly that you have now a design that will do the job?

A Yes sir, and that will be illustrated later on.

Q But you are looking for possible other designs that will do the job just as well and be more economic?

A Yes, and confirming if in fact that design would have to be implemented at that river crossing.

Q Can you help me on the expression, "parametric analysis"?

A Parametric analysis would mean that we would take the factors that have a bearing, for instance, on slope stability such as soil strength, and the components that make up that strength, and we would look at it over a range of

values, if you like.

Q From the worse case to the best case?

A Ye s sir.

Q Something like that?

A Yes sir, and we would vary such things as the internal pour pressure, the friction angle of the soil, these are all parameters that are used in slope analysis.

Q Now I interrupted you, about the Great Bear crossing.

A Yes sir. Now morphological data has been gathered in river crossings where required. Preliminary design work carried out to date has defined the requirements for final design. Additional ground truth and test data are required before detailed design and/construction specifications are completed.

Q Let me stop you again. I'm sorry, Dr. Clark, you have two expressions here that I find hard to understand. "Morphological", I'm sure everybody else is, if nothing else, but I have trouble --

A Well, very simply, "morphological", that is the channel -- river channel geometry, the land forms that make up the river.

Q And what is "ground truth"?

A It's site verification, generally test holes. It might be examination of

exposures on ground, collecting ground evidence by being actually on the ground.

Q Oh, I see, so is the use of the word "truth" to say -- to indicate that you're proving the truth of your predictions, your --

A In a sense, with respect to the terrain analysis, it's common to say that we do ground truthing, this means going out and drilling test holes and perhaps doing other types of tests to verify the terrain typing.

Q When you say additional of these are required before the detailed design and construction specifications --

A Yes sir, the test drilling will be predominantly at specific sites where information is required for final design of foundations, for ancillary facilities, for gravel pads, airstrips, roads, etc. We will also be drilling and testing at river crossings and slopes, which are judged to be potentially unstable. The site specific drilling will be completed in sufficient time to allow detailed specifications to be prepared for all facilities Its not expected that a great deal of additional drilling will be required for the pipeline route itself, and here I'm speaking of the overland areas. It has been argued that the terrain typing and verification test drilling would prove adequate for most of the final mile by mile design.

Q How do you plan, Dr. Clark, to account for unforeseen terrain conditions

at specific locations?

A Well,we regognize that it's not possible to anticipate all terrain conditions prior to start of construction. Detailed specifications will be available to cover all ancillary facilities of construction, such as compressor stations, such things as pipeline burial depth, slope stabilization requirements and so on. However, in some instances,conditions will be encountered which differ from those upon which the design are based. Therefore a design change manual which will be available prior to start of construction, will account for most changes necessary. For example, if conditions vary substantially from the original test borings, over the area of a compressor site, for instance, the manual will outline adjustments required for changes in pile length or spacing, perhaps it would be necessary to put in more piles. IN other cases such as slope stabilization measures, if conditions vary from those anticipated, it will be necessary for the geotechnical engineers to adapt the design.

Q That would not be covered by a design change manual.

A No, not such a thing as a slope stabilization.

Q This design change manual, can that be developed before final design?

A No, it is developed after final design. Our efforts now, all of these studies which we have described, lead into the developmen t of a design manual, and concurrent with this and more so

in following this we will have a design change manual which would correspond to the design manual, to account for unforeseen conditions.

Q so before you get the final design, you will have to have what's called a design manual?

A Yes sir.

Q What will that show?

A That will show such things as the methods of anchoring the pipe to resist buoyancy in certain areas. It will outline the radius of curvature that can be followed in certain terrain types for pipe bends. It will cover foundations. It will generally cover slopes. It will bring together into one document virtually the summary of the work that has been done to date and the work that will be done between now and the start of construction.

Q Who will be the users of such a manual?

A Well, the design manual is largely intended for use by the staff engineers in completing the design and specifications for the specific cases, such as compressor stations and so on. The design change manual would be used in the field by the inspectors, and geotechnical personnel charged with the responsibility of seeing that the designs are properly implemented.

Q What geotechnical control will be exercised during construction?

A Well, there will be two distinct levels of geotechnical design control. Qualified geotechnical engineers or inspectors attached to each construction spread will be directly responsible for the on-site verification of design assumptions, and modes, and for any consequent modification and configuration, if required. Decisions in this regard will be mainly by visual inspection of the ditch wall during the pipe-laying operation, inspection of cuts in approaches to river crossings and so on. Drilling would be carried out wherever necessary. There will be some latitude for modification to design configurations in regard to depth of cover, method of pipe restraint, field bend angles and shallow slope stability, but they're directly related to the permafrost and soil conditions exposed in the ditch.

While pre-construction design will have isolated the major design configurations in relation to the ground conditions encountered, minor changes are inevitable. However, the range of possible deviations and required on-site response will be covered in the design and field manual with the field engineering staff responsible for their use. In turn, the design engineering staff will monitor the control being exercised by on-site staff, especially in relation to field modification. Now this is one level of control.

The second level is the direct geotechnical design control which would be undertaken by the design engineering staff, if

required. The major thrust of the design phase will of course be to obviate the requirements for such control, but in certain areas such as in major river crossings, close inspection and verification would be undertaken by the design engineering staff.

Q I do not understand the sentence that you just quoted or stated, Dr. Clark, that "the major thrust of the design phase will be to obviate the requirement for such control," what do you mean by that?

A WEll, for example, at river crossings, the design would be to a level of detail where it would be very clear and straightforward. Another example on the design of foundations for structures, we would expect to have site specific information, we know what is in the ground, we also know what loads have to be carried by the foundations and the foundations would be designed in detail and specifications would cover their installation.

Q So then the people in the field then merely have to follow the detail specification and have little discretion left to them?

A That would be the Objective, yes, sir.

Q Yes. Do you anticipate, Dr. Clark, that further information will be gathered prior to and during the course of construction for use in maintenance and operation of the pipeline in future years?

A Yes, sir. A detailed catalogue of the permafrost and soil conditions found and adjacent to and along the right-of-way, obtained prior to and during the construction of the pipeline, will be assembled. Now this includes

--

Q You have been cut off.

A It will also be maintaining a record of conditions in the ditch wall on a mile by mile basis similar to that illustrated by Mr. Williams where he showed you a profile of a ditch wall. However, it would not be to that same detail. It would not be to a research level. The frequency of the recorded observations in the ditch will be determined by the natural variability of conditions and the potentially troublesome sections. Detailed records of the results of drilling programs undertaken for the design of all other structures such as compressor stations, runways and so forth, will also be incorporated into the data system. Now, the exact nature of the data retrieval system is under study; It is very likely to be found appropriate to structure part of the system to a facility basis, for example, all of the information collected for a given compressor station and ancilliary structures will be included in order that at any time we would know from our data retrieval system all of the geotechnical data that has been collected to that point of time at that site.

Q Well, the object of this, then, Dr. Clark, is to have logged as you go along, a diary of all the conditions you encounter on every mile of the right-of-way, have I got that correctlY?

A That is right, sir, and the frequency of observation would naturally depend

upon the variability, but at any point in time in the future operation we would want to be able to use -- we would want our data retrieval system to be able to tell us what exists at any mile post or any point on the line from the observations that were recorded during construction of the ditch.

Now, certain types of information such as hydrologic data from the basins and changes in river morphology need to be gathered over a long period of time. Ice jam data along the Mackenzie River is being collected and this will also be continued during construction. Now, these data are needed for the design and will be valuable in establishing a maintenance program for river crossings and wharves.

Q What steps will be required to be taken, sir, to assure proper drainage and erosion control during the ocnstruction and operation of the pipeline?

A The preliminary assessment of the degree of drainage and erosion control requirements has been included on the alignment sheets using a number of categories based on the site specific terrain information available at this time. The location and type of control measures will be determined using the design flows in conjunction with terrain data obtained during drilling programs.

Although most of the design will be conducted in the office, final

location will be determined and flagged by ground survey during the summer proceeding construction when minor drainage courses are not hidden by snow.

Now, the principle objectives of the measures will be to control all surface and sub-surface drainage flowing across the pipeline right-of-way and across other areas disturbed by construction. Consideration will also be given to the stability of other adjacent areas that have been disturbed in the past and that could erode during the lifetime of the pipeline.

In the long term, revegetation will provide an erosion resistant surface, but other measures will be necessary immediately after construction until the revegetation is established. The principle method will be to provide frequent breaks in the back fill mound and to line these with a protective layer of non-erodable soil. Other measures which are described in the application will be used in more critical areas to collect flows on the upslope side,to direct them across the right-of-way and to dissipate the energy of the concentrated flows into the undisturbed area on the down slope side of the back fill mound.

These measures will be illustrated later in the slide show, sir.

THE COMMISSIONER: Excuse me again, Dr. Clark, forgive me for interrupting, but this will be the first pipeline in Canada which

has been built in continuous permafrost.

A Yes, sir.

Q It will be the first pipeline in Canada that,in which the gas has been chilled.

A That is correct, sir.

Q Will it be the first 48" pipeline in Canada?

A I believe there are 48" sections. Maybe Mr. Williams could comment on that.

WITNESS WILLIAMS:

A Yes, I am fairly certain that the Interprovincial Oil Pipeline has some 48" pipe in their system.

Q Well, is this going to be Canada's first 48" gas pipeline then?

A Certainly in the pressure range that we are talking about, yes.

Q Well, I do not want to leap ahead but I gather that the pressure will be greater than that of any gas pipeline in Canada, that is true I take it? That is true, is it, Mr. Williams?

A It is certainly greater than the large transmission line systems that I am aware of, yes.

Q Yes. Well, on page 17, Dr. Clark, I -- notwithstanding the spontaneity of the questions and the answers -- they have a tendency

to --

MR. GENEST: I hate to be blamed fot that. We are required to give our evidence before time.

THE COMMISSIONER: I got into the habit of reading on ahead, that is the only reason I am coming back, but it says on 17, "Certain types of information such as hydrologic data from basins and changes in river morphology need to be gathered over a long period of time. Ice jam data along the Mackenzie River is being collected and this will also be continued during construction. These data are needed for design and will be valuable in establishing a maintenance program for river crossings and wharves."

Is there any other gas pipeline in Canada that entails river crossings of rivers such as the Mackenzie? An Arctic river, in other words?

WITNESS CLARK:
A Not an Arctic River that I Know of, sir, flowing in that direction. There are many pipeline river crossings that encounter similar problems, but the size of the river here is much greater and the fact that it flows in the north-south direction is a -- makes an unusual problem.

Q Creates the ice problem?

A Yes, sir, that is correct.

MR. GENEST: South-north direction.

A Yes.

THE COMMISSIONER: Well, I donot understand something here. You say, "Ice jam data along the Mackenzie River is being collected and this will also be continued during construction. These data are needed for design."

A Yes, sir, we have had ice break observations going on and they will be carried on. The designs that we have developed now, have taken that into consideration and we believe it to be on the conservative side. We think that by the time of construction -- we may have advanced to the point where we can improve that design, a refinement in which it would be less, less conservative possibly.

THE COMMISSIONER: I see, well -- carry on.

MR. GENEST: WEll, perhaps if I may just follow up on that, sir, perhaps the Commissioner is sharing my question at this stage, that you have said that you have designs that are suitable and can make this pipeline geotechnically sound, if that is the proper expression --

A That is right, sir --

Q -- in the NOrth, and then we run into a statement that you need some more ice jam data for your design and there seems to be a little contradiction in those two statements.

A Well, I guess the emphasis there that is perhaps in establishing a

maintenance program. We have ice jam data now. I believe it is Dr. Cooper or Dr. Hollingshead that will be speaking to this in more detail when we discuss river crossings, but these data have been collected by ourselves and by others. You can get historical evidence of ice jams by examining sites, for instance seeing where trees have been affected by high water, high ice levels in previous years and all of these have led us to, what we believe is a conservative design.

Now, we are also doing modeling of this -- not a physical model -- in order to be able to predict flow and scour. Now, it would be a case of collecting more data to assess that particular model to see if we can produce a refinement in that design.

Q Well, I think that I understand, you say that you have made a conservative design and does that involve your parametric analysis, you have taken the worst case?

A Yes.

Yes sir, I believe Dr Cooper can amplify on that now or during his slide presentation.

Q Well now it is on our mind, if I can pursue it, your designs have assumed the worst case.

A We believe that they have, yes.

Q And when you say that you're looking for further information, it's not to help you find a design, it's help find some other kind of design.

A A refinement, sir, yes.

Q Refined from what point of view?

A From what we have now, that it might perhaps be possible to do a more economic -al crossing than we have now.

Q So this data then, is it required to have you cross the river at all, or is it required to have you devise a more economical way of crossing a river?

A The latter, sir. We believe we could develop a design now to cross the river safely.

WITNESS HARDY: Perhaps I could add, M r. Genest, that the practice that is being followed here is not completely unusual, as far as some pipeline designs are concerned. A point that I would emphasize in what Dr. Clark has said is that

they are proposing to set up facilities that will monitor the developments in the river to a degree that has never been undertaken in any previous trunk line in Canada. Now in the case of river crossings, and I have done myself and in co-operation with other people, several dozens of major river crossings, we have never had a failure due to the under-estimating of the scour protection. We have had failures because the characteristics of that river were not accurately enough known, and it's been out-flanked.

Now the thing is that some of these can be -- many of them, in fact, could have been prevented if there had been more routine data collected with the idea of building up a background of knowledge within the pipeline organization. On top of that, if they're monitoring the performance of a river, if they are in a season where there are extraordinarily severe ice jamming, they can protect their crossings on an emergency basis probably by blasting and so on so this is not a completely new concept that they have come up with a design and that they still have to find out what the river characteristics are. They don't know all they would like to know about the river, but they think, as you stated, they think or asked the question, I think Dr. Clark has said he thinks he has a conservative design. I think that looks after it as far as I am able, sir.

Q I think that we were at -- we had left erosion.

WITNESS CLARK: Yes sir.

Q You were going to illustrate later with some slides and we had interrupted you, and I might say, sir, that I certainly welcome, for my part, these departures from the prepared text. We were at river banks.

A Yes sir, the river banks at crossing sites will be protected from river erosion by bank arming such as rip-rap or by river training measures, where required. Now at river crossings temporary river control structures required during construction will be designed to have a minimal effect on the erosion of natural river banks. These temporary structures will be removed following installation of the crossing.

Q What kind of temporary structure, just briefly, are we talking about?

A This could be a berm for instance, built out in the river to facilitate construction, and then it would be removed at the end of construction.

Where the installation of a river crossing alters the resistance to erosion of the natural river banks, erosion control measures will be employed. The most common will be rip-rap for bank revetment. In some cases where the natural banks are highly susceptible to erosion, such measures will be used to ensure safe designs. Now frequent inspection and maintenance of the control measures will be

essential during the years following construction to ensure that conditions condusive to rapid establishment of the revegetation measures are maintained. Unless the erosion is severe, the remedial measures will be applied during winter when access will not cause further disturbance.

Q What steps will be taken, Dr. Clark, either during the construction or the operational phase of the pipeline to ensure the proper stability of the pipeline? Perhaps before you launch into your reply you might tell me what I mean by the proper stability of the pipeline?

A Well, stability would relate for instance to slope stability, the resistance to bouyancy the keeping of the pipe in the ground would relate to pipe stability.

Q Right.

A So the overall objectives, of course, in the design are maximum human safety, the minimum disruption to the environment, and a secure and reliable pipeline system. Our planning and design process has and we believe will continue to seek the best available technology for the location, design and construction, and the operation, and will talk about these aspects later. From a geotechnical point of view there's a wide range of natural phenomena such as slope stability, river hydrology, surface and sub-surface drainage, the freezing and thawing of soils, and so forth, all of these are natural phenomena which can

be affected by the construction and operation of a chilled gas line. Now then there is a complimentary range of created factors such as the soil pipe inter-action, the pipe floatation foundation and river crossing design which must be considered in the planning and design process. The approach that has been taken in the design of the pipeline is to recognize and define the complete range of potential problems and to obtain a detailed qualitative and quantitative understanding of the factors governing each problem area.

Now a fundamental part of the approach to ensure the stability of the pipeline during construction and after start-up was simply to avoid problem areas. This approach represented a major component of the planning and design process. Many problem areas can be simply avoided by judicious route selection. Where the proposed route runs with the grain of the land, this can be accomplished economically and marginal areas can be avoided with ease.

Now where problem areas must be crossed, preventative measures are available that are both environmentally and economically acceptable. These measures require the modification of natural conditions or a change in design mode.

THE COMMISSIONER: Q What do you mean the grain of the land, running down the valley?

A That would be right, sir. With respect to stability of the pipeline, there are two distinct periods of concern in permafrost regions, the time between construction of the pipeline

until startup, and that is there is no gas flowing, and the time after the pipe becomes fully operational. A range of situations must be considered during all stages of the operation. However, it should be noted that the design configurations that had been devised to handle the pre-startup conditions, will still be intact and operated if a major upset causes thawing sometime after the line becomes operational. That is the measures that we develop to resist buoyancy will still be operative, for example.

Now the recognition of the possible requirements for upset and contingency repairs has developed -- has resulted in the development of an operational and maintenance plan. Now clearly no single emergency plan can be developed because of the wide range of physical conditions encountered and the seasonal variation of these conditions. The early identification of problem areas is of vital importance and a line patrol system will be used to monitor the right-of-way. One of the responses to a question by the pipeline application Assessment Group,question 55, provides more detail on the proposed monitoring.

Q What steps, Dr. Clark, will be required to ensure the adequacy and stability of access roads and all these ancillary facilities, snow roads, air strips, compressor stations, communication towers, wharves, during the construction and operation of the pipeline?

A Each of the facilities will be the subject of a detailed design and construction specifications. A brief description of the design approach for each follows: First access roads and air strips. Similar approaches to the design of roads and air strips will be adopted to those currently in use in Arctic Canada and Alaska. The sufficient thickness of non-frost susceptible fill designed to prevent undue thawing of the underlying natural permafrost will be placed on the natural organic surface. The use of a layer of material with high insulation value may also be considered in some areas where marginal permafrost conditions are present. Drainage systems will be employed to accommodate the anticipated surface water run-off in the area. In locations where unexpected thaw of the sub-grade soils develop, and settlement of the fill surface occurs, maintenance will be employed to bring the fill surface to its original level.

With respect to snow roads, they will be built to conform with highway geometric design and to increase the resistance of the surface through the motion of heavy equipment. Tests have been carried out on snow roads in different locations. High strength properties were obtained for the snow road surfaces, showing that snow roads are capable of supporting high contact pressures, thus demonstrating their suitability to the movement of heavy vehicles. On cross-slopes, fill construction will be used to obtain level roadway surfaces.

The compressor stations, the foundations for the compressor stations located on sites where significant thicknesses of permafrost are present will be designed to maintain the underlying soil in its frozen state.

The introduction of an air space between the heated compressor building and the frozen ground will ensure that the surficial layer of soil that melts in the summer season will re-freeze during winter. Whether the foundation involves piles or fill pads, the stresses imposed by the structures will be limited to provide a reasonable safety factor against the occurrence of sheer failure or excessive settlements in the soil.

Q What's sheer failure, Dr. Clark?

A Sheer failure is where there would be an actual slip between the pile and the soil, where the allowable stress, the maximum stress is exceeded.

Q And how do you introduce an air space between the Compressor Building and the ground? Just put it up on stilts?

A It would be up on piles, yes.

Q Just like my old summer cottage.

A Something like that, sir. There are many buildings, there are examples of these buildings in such places as Norman Wells, Inuvik and

so on.

Now in marginal permafrost areas where the ground temperatures are close to the melting point, refrigerated piling, end bearing piles on rock or unfrozen hard material or fill pads may be considered, if necessary.

For communication towers, they usually involve relatively light loadings imposed on the soil. The principal design consideration is the uplift forces on anchors for guide towers. The grouted wrought anchors have been used successfully in Arctic Canada, and design methods and parameters are currently available for assessing the capacity of such anchors in permafrost. Footings or anchors used for the support of communication towers will be found at below the maximum depth of thermo-distribution caused by the above-ground construction procedures.

Wharves will be required along the Mackenzie River and Arctic coast. These may be either temporary structures for the construction period, or permanent installations. The structures will be located to minimize the interference with the flow of the river. They will be designed to be overtopped by the flowing ice during breakup, if possible.

Alternatively, removable pontoon type structures may be used as either floating or grounded wharves, which will be placed in the river following breakup and removed before freezeup.

Q Can you comment, Dr. Clark, on the foundation design techniques that are going to

be employed with respect to the construction of structures, facilities such as compressor stations in the northern parts of the pipeline.

A Yes sir, in areas where the permafrost is absent, the foundations for pipeline facilities will be designed in accordance with the conventional practice currently in use in temperate regions. The foundation design will account for frost penetration that occurs in these areas, in the top few feet of soil during winter months. Heavily loaded structures will be supported on sill pads or pile foundations, depending on local soil conditions; whereas lightly loaded structures may also be supported by spread footings.

Now in permafrost areas where frozen soil and ice may be present, within the soil mass supporting the stru cture, a number of design approaches are available where clean, well-graded coarse-grained soil with no excess ice are known to be present, foundations may be designed to permit thawing of the underlying frozen soil. The allowable load-bearing capacity of the foundation will then be governed by the properties of the unfrozen soil.

Now where significant ice contents are present within the sub-soil, and large settlements would occur on thawing of the sub-soil, the foundation designs will be based on maintaining the permafrost in its frozen condition. In these cases the geotechnical properties of frozen ground will govern the allowable loading that may be placed on the

foundation systems.

Q How do you do that, Dr. Clark? How do you design a foundation to maintain the permafrost in its frozen condition?

A Well, there are several ways of doing this, one is the introduction of the air space, for instance. In other cases there are situations where refrigerated piles have been used to maintain the ground in the frozen condition. There are several techniques of doing this.

Q How do you refrigerate the piles?

A Well, there are very large refrigeration plants at the compressor sites. One way would be to tap off some of that refigerant. We have looked at the requirement to maintain an entire compressor station area, all the piles frozen, using the same refrigerant, and it's some very small fraction of what's available. Another is to use the nature, there are piles that have been developed, for instance, for the Aleyeska line which are patented, I believe, by the people that developed them, that have a technique of circulating a refrigerant when the air temperature is very cold, and this cools the soil around the pile and circulation automatically stops when the air temperature warms up. The theory is that during cold ambient temperatures, the ground is chilled; and during warm ambient temperatures there is no major transfer of heat by the refrigerant fluid.

Q Would you proceed, sir?

A Yes. Foundation design in frozen ground will satisfy some of the criteria of those used in temperate regions. That is to say, to limit the foundation loading, to prevent sheer failure in the soil mass, and to limit settlement of the foundation to an acceptable level.

In addition, foundations will be designed to resist uplift forces resulting from frost heaving and re-freezing soil in the active layer. As the deformation and strength properties of frozen soil are known to be heavily dependent on temperature, a knowledge of the thermal behaviour of the sub-soil over the life of the structure is an important additional feature introduced into Arctic foundation design. The geothermal models apparently available are capable of solving a wide variety of thermal problems in soils.

Q What you're telling us here, then, sir, is that your computers can again predict --

A They are applicable to the foundation problem as well as the pipeline situation, yes. The predicta power of these models have been checked and found to be in agreement with observed field behaviour. Now pile foundations will form a considerable portion of the support systems adopted for the pipeline facilities. If bedrock or other firm strata are accessible, end-bearing piles will be founded on the strata. In cases where no

stiff strata are easily accessible, pile foundations will be designed to transmit structural loadings to the sub-soils through the shaft of the pile. In other words, instead of transmitting the load to the end to a hard material, it would be distributed -- designed to be distributed along the shaft and spread out throughout the depth through which it penetrates. The stresses along the pile shaft will be limited to prevent sheer failure of the pile soil interface, and to maintain pile settlement within tolerable limits.

The use of fill pads for heavily loaded structures will also be considered and such foundation systems may incorporate a system of ventilation or insulation or refrigeration to maintain the permafrost in its frozen condition. There are several methods of maintaining the permafrost under fill in a frozen condition, as well.

Q And these are in use, these are well known?

A Yes, and I believe that some examples were given by Dr. Legget in his overview remarks last -- or a week ago last Saturday.

Q Next, Dr. Clark, I'd like you to discuss the question of the depth of burial and its influence on geotechnical considerations. That's depth of burial of a pipeline.

A Yes sir. Now the geotechnical design of the buried chilled gas pipeline is facilitated by increasing the depth of burial to

within the limits allowed by the wheeled ditchers that have been designed for use on this project. Now depths of burial to the top of the pipe of up to six feet below original grade can be readily achieved, and the resultant depth of cover above the buried pipe at this depth of six feet is in the order of 7 to 9 feet when the native backfill derived from the ditch excavation is put back over the pipe.

Now depth of cover of five to six feet achieved at a depth of burial of four feet, and I should perhaps clarify that the depth of burial is the depth of the top of the pipe below the original ground surface, the depth of cover includes the spoil mound which is mounded up over the pipe. So the depth of cover of five to six feet achieved at the depth of burial of four feet is adequate in all permafrost zones and terrain types in restraining potential pipe floatation prior to startup of the chilled line when the line is restrained by the frozen ground.

Q That -- of course there will be some period when before you start running chill gas in that pipeline when you'll have problems which are not present when the pipeline is chilled.

A That's right, sir, there are these two periods of concern, one from the end of construction to the time of startup, and the other is after startup when the gas starts to flow.

In the more northern regions

of the right-of-way, that is continuous permafrost zone in the extreme northern portions of the discontinuous zone, a burial depth of four feet ensures that the pipe remains frozen to the bottom of the ditch, thereby effectively preventing floatation. Now in the region south of this zone, although the possibility exists that thaw may proceed to below the buried pipe, studies have shown that a native backfill at a four-foot burial depth is adequate restraint against floatation in all but the most ice-rich terrain. However, terrain analysis shows that very ice-rich soil should not generally occur in the more southerly areas. If they are encountered, the depth may be increased or a range of other design techniques to prevent floatation are available, and I previously mentioned several of these.

Q That's the concrete and the weighting and the anchoring, and so on.

A Now, the increased depth of burial also increases the stability of field bends for both sag, side and overbend configurations. Increased depth that covers is also desirable in the prevention of pipe instability due to temperature expansion, internal gas pressure along straight, buried sections.

Q Would you explain those, sir, what is instability due to temperature expansion?

A Well, the stresses that are induced in the pipe are due to the internal pressure, plus the difference between the temperature at which

the pipe is laid into the ditch and at which it's operated. This induces a stress in the pipe. For example, it may want to expand, and this expansion is resisted by the -- to some extent by the bond of the surrounding soil to the pipe, and it bends by the strength of the ditch wall, acting to resist this lateral force. All of these increase with increased depth of burial.

Also the increased depth of cover in the depth of burial increases the total vertical load which is acting on the bottom of the pipe, and this is of considerable importance to us in suppressing potential frost heave in unfrozen soil, as will be demonstrated later.

In some instances, increased depth of burial is of value in reducing the potential effects of differential settlement. Although there is little likelihood of excessive differential settlement due to the thermal regression of permafrost during the operation of the chill line --

Q Whoa. Can we just stop for a moment and let us know what thermal regression of permafrost is?

A This is the thawing out of permafrost under the line. This, of course, wouldn't happen when the line is carrying chilled gas, but prior to startup it may happen beneath the line.

THE COMMISSIONER: Thermal regression is melting?

A Yes. The retreat of the permafrost table away from the line.

MR. GENEST: It takes a lawyer to be that simple. I am sorry, Dr. Clark, I withdraw that.

THE COMMISSIONER: Well, to be fair I think it means tht the actual, the substance contracts or is -- recedes from the pipe itself, that was the point I take it?

A That is right. There is a regression under these series.

Now as the ice content in permafrost soils along the right-of-way usually decreases rapidly with depth, the increased burial depth will significantly reduce the potential for differential settlement due to melting out of ice. In other words, the deeper we go, the less ice is encountered.

Now, there is a possible exception where differential settlement could be of concern, that is the peat plateau areas in the vicinity of the Northwest Territories/Alberta border. These plateau contain peat and fine grained soil which may have/high ice content. A preliminary assessment has been made of this area and the current plan is to bury the pipe at a common depth dictated by the presently thawed areas between

the plateaus, that is to say, it will be at greater depths through the plateau area. Now, these areas are currently the subject of further investigation. Differential settlement can also occur due to loss of ground support resulting from erosion. WEll, erosion prevention forms an important aspect of the geotechnical design of the right-of-way, increased depth also aids in this regard.

Now, in coarse grained gravelly or boulder rich terrain it is likely that the wheeled ditchers developed will not be used.

MR. GENEST:

Q Did we see that wheeled ditcher on Mr. Williams' slides?

A You saw a certain model of that. There has been developments. Larger ditchers have been developed since that time.

Q It is the same idea.

A It is the same idea, yes, sir.

Q And you propose not to use --

A This would not be used in certain terrain units, for instance, in very boulder rich terrain or bedrock for that matter or in certain coarse grained gravelly materials, although recent experience with the existing larger ditchers have indicated that it digs gravel very, very well, but in these areas the importance in pre step to burial is not as great and can be relaxed.

The resulting back fill such that the pipe stability is insured at lesser burial depths with 2.5 feet is considered as the allowable minimum depth of burial in that type of terrain. Conversely it can be noted that in the ice-rich or fine grained soils in which the pipe stability requires slightly greater depths of burial, the required burial depth can be achieved with ease using the wheeled ditchers being developed for this project and as you saw an early version of the ditcher that dug fairly well at the Sans Sault Test Site.

Q If you do not use the wheeled ditcher, what do you use?

A It is largely a case of blasting and back-hoe to get to the depth required in those circumstances.

Q Not a shovel?

A No, sir.

Now, in active river and floodplain areas the pipe will be buried sufficiently deep to ensure against exposure as a result of scour and degradation. On all major river crossings the required burial depth will be based on a site specific assessment of the potential for scour and on degradation. On very minor river crossings where no significant scour or degradation is anticipated, the pipe will be buried so the cover will be at least 4 feet.

Floatation of the pipe will be prevented in active river and floodplain areas

by the use of continuous concrete coating or suitable anchoring techniques.

Q Could we move then, Dr. Clark, to the interior route, that is the one going past the Old Crow Flats and across the Richardson MOuntains. I would like you, sir, to describe the geotechnical work that has been done with respect to that route.

A Well, the geotechnical investigations along the Interior Route were essentially of the same level of detail as along the Coastal Route. They were oriented toward classifying and mapping terrain and identifying potential engineering problems which might result at specific localities.

The airphotos, the geologic publications and drilling logs were the basis for terrain classification and mapping done by J.D. Mollard and Associates. The results of the terrain analysis which are at a scale of one inch to 2,000 feet appear on the photomosaic alignment sheets and in the terrian typing legend. These were discussed during the first panel. Now, specific details on landform, bedrock and soil materials, stratigraphy, depositional history, permafrost, topography, drainage and vegetation were determined for major terrain units mapped on the alignment sheets. Information on areas where specific geotechnical problems like buoyancy, erosion control, slope stanility, and unstable water courses where these will be encountered were also

shown on the alignment sheets.

Now, field studies along the Interior Route have provided information on terain classification and for the preconstruction geotechnical studies. These field studies included drilling programs by Alaskan Geological consultants and Northern Engineering for the Alaska Arctic Gas in Alaska and studies by Ripley, Klohn and Leonoff for the hot oil pipeline feasibility studies by MVPRL, the Mackenzie Valley Pipeline Research Limited. All these test data were made available to us for our use.

Now, another field study by T. Blench and Associates and Northern Engineering provided data on river crossings.

The seismic design criteria through this area has been developed by expert consultants on the basis of data compiled by Arctic Gas

Q Is there anywhere else we discussed the -- I know Mr. Gibbs in his cross-examination of the first panel made some point of the seismic risk in this area. Dr. Morgenstern, I see by your publications that you have had something to do with earthquakes or the study thereof. Could you comment briefly on the degree of risk?

WITNESS MORGENSTERN:

A There is -- no doubt there is a higher seismic risk associated with the INterior Route than with the Prime Route, but

the risk is certainly no greater than had been faced by the Alaskan Pipeline and design procedures have been developed to accomodate the degree of anticipated seismic loading on both the pipe and ancilliary facilities.

THE COMMISSIONER: By the Alaskan Pipeline do you mean the Alaska Gas --

A I am sorry, the Alaskan Oil Pipeline which has faced more severe earthquake problems than we encounter here.

Q Well, that is an oil pipeline above the surface of the ground.

A Well, not all of it. About half is buried and half is on piles.

Q I see. From the point of view of seismic risk does that make any difference?

A Yes, they -- much of the right-of-way along the oil pipeline will be thawed more than along the gas pipeline because of the construction practice that they have chosen to adopt. Many of these thawed sediments are prone to a phenomenon called liquifaction that occurs during an earthquake. The material turns into a slurry due to the cyclic loading of the earthquake. This problem is going to be less severe along the right-of-way of the gas pipeline and of course will not effect the integrity of the gas pipeline itself because it will be encased by frozen soil, so that generally a buried chilled pipeline can respond

to earthquakes better than a buried hot oil pipeline.

MR. GENEST:

Q And while we are on the subject of earthquakes, what are the risks associated from an earthquake or seismic point of view with the prime route we have selected. Is it in an area of high or low risk?

A Part of it is in an area of moderate risk. The zoning that has been adopted in design has been presented. The actual boundaries of the zones escape me, but where we come down along the flanks of the Richardson Mountains just on their east side, there is a defined earthquake risk and earthquake loading that has been embraced by the design.

Q And what about for the rest of the route down the Mackenzie Valley?

A It is very low.

THE COMMISSIONER: When you say these problems have been overcome in the construction of the Aleyska Oil Pipeline you mean that they have worked out and eleborated design solutions that they believe and you believe too will eliminate the risk of failure in the oil pipeline in Alaska owing to seismic activity?

A Yes, the procedure is to anticipate the loading that the earthquake will bring on the gound and on the pipeline and very conservative, that is high levels of loading have been adopted there and design has been developed to accomodate these

levels of loading.

MR. GENEST:

Q Are there gas pipelines or oil pipelines in the more southerly parts of North America that cross more risky seismic terrain?

A There are pipelines in California of course which is quite seismic.

Q How would you grade the seismic risk in California as compared to that which exists across the Richardson Mountains?

A Well, part of it is comparable, part of it is greater. California itself is variable in its seismic risk.

Q And are there instances of serious interruptions due to seismic activity, earthquakes?

A Generally speaking a pipeline is a very flexible entity and they can deform quite well even across active fault movements. But I am sure if I were to do a little research I could find instances of pipelines that have failed during very severe earthquakes.

Q What are the repair problems?

A I cannot speak to that.

Q Perhaps shall I just let that hang there? It teaches me a lesson for departing from the script. Nobody is going to bail me out.

A Next panel, sir.

Q Next panel.

(LAUGHTER)

WITNESS HARDY: There were pipelines in Alaska at the time of the Good Friday Earthquake, of ten years ago or 12 years ago, and my understanding is, I think Dr. Morgenstern can substantiate this, or correct me, is that their performance was relatively good, and there are many authorities that consider that the only hazard to a fracture of a pipeline in an earthquake of even quite high intensity is only where it crosses a fault, and so it's not -- the risk of fracturing a pipeline is relatively small considering the pipeline as a type of structure. Now the repair, of course the pipeline does get broken and the problem is then to repair it, and that of course would be relatively simple if the earthquake didn't destroy other facilities, but other facilities will probably suffer far greater damage than will the pipeline. One of the things that keeps coming up in engineering is that when we get greatly concerned about the hazard from seizmic activity to a certain type of structure. You see, the damage to that structure may be very minor compared to other damage that is created in the community at the same time.

So I think in direct answer to your question, what's involved in the repair, they just have to get in and take out some pipe and put in some more. But then with the conditions associated with that seismic activity, that damaged the pipeline, that may be a difficult operation and there may be other things that are -- would have even greater urgency of attention than the pipeline itself.

THE COMMISSIONER: Water supply and so on.

A That's right.

WITNESS CLARK: I should add perhaps, Mr. Genest, that the information provided to us for design indicates that we cross no recently active fault on either pipeline route. We recognize that if the interior route is built, we will have to do further field work to verify that there are in fact no faults. If we do encounter a fault, we believe we have developed a design which, if that fault were to move, that the pipeline would come out of the ground without failing, that it would not be bound in place, and as Dr. Hardy pointed out, it's at these faults where the only area of concern is for the pipeline itself, the line in the ground.

Q Thanks, Dr. Clark and Dr. Hardy. Would you carry on? We were discussing, I believe, the geotechnical work that's been done with respect to the interior route, and I took you down a long path about earthquakes.

A Yes, sir. To continue on, the preliminary design for terrain stabilization has been developed from office and field studies for both the coastal and interior routes. These design measures are related to drainage and erosion control, slope stability, pipe buoyancy, especially in the thermal intensive terrain units.

Excuse me, the construction techniques for access roads, gravel pads and foundations of structures have also been devised with consideration to geotechnical problems that might result at specific locations.

Q As a result of the geotechnical work that's been done with respect to the prime route, that is the coastal plain route and the interior route, which in your opinion is the preferable route from the geotechnical standpoint?

A In my view the pipeline route across the coastal plain is preferable to the interior alternative. The coastal route would be much easier to construct and rehabilitate than the interior route. It presents no major problems. The interior route is feasible, but more geotechnical problems would be encountered. The route, for example, would cross talus slopes which would be very difficult to cut and maintain stability. Such slopes would require a stabilizing berm at the bottom, to cover and support the pipe. The berm would necessitate the use of greater quantities of gravel fill along the route,

necessitating blasting and probably greater terrain disturbance than would be expected on the coastal route. Now the seismic risk through the Richardson Mountain is the greatest for the routes considered, but design techniques are available to deal with the potential problem areas. The interior route also crosses numerous alluvial fans . Some of the fan crossings will require special erosion control measures to prevent channel degradation during a prolonged sequence of flow or moderate floods.

Q What type of special erosion control measures do you have in mind?

A Well, they would be along the lines of those that we have discussed and will be illustrating. For instance, measures to prevent the flow over a fan becoming concentrated down a pipeline and washing out the backfill, to prevent shifting of channels and so on that might undermine in certain areas. These fans are a more dynamic land form in that particular part of the interior route.

THE COMMISSIONER: Just going back for a moment, you said that in the Richardson Mountains the route would cross talus slopes. I take it that's fallen rock.

A Yes sir. These are the slopes that one can see on any mountain area at the bottom, it's rock that due to weathering and so on, it drops away and builds up at the bottom on fairly

steep slopes, generally in the range of in Arctic areas, 35 to 37 degrees. We have measured them up to 41 degrees.

Q So it is unstable?

A Unstable under its own weight, but if one were to cut into it, the material above could become unstable. There havebeen talus slopes crossed, though, with pipelines, and successfully. These are quite steep,these slopes.

Q You said that you would have to construct a berm at the bottom, that is to restrain the rock from falling and to restrain the slope from receding?

A Yes, we would visualize the -- from the geotechnical point of view we would visualize the design of the pipe would be laid very close to the bottom of this slope, and similar material as the talus or gravel would be used to build up and over the pipe a bench, if you like, at the bottom, which would contain the pipe through that area.

Q You say that pipelines have been built in Canada to cut across talus slopes. Westcoast for instance?

A I believe so. I've discussed this with Dr. Hardy some time ago, and I recall some discussions on that.

WITNESS HARDY: I think, Mr. Genest, to put this in its proper context, --

MR. GENEST: The Commissioner asked the question.

WITNESS HARDY: Yes sir. To put it in its proper context,we sort of set up a straw man here. It probably came about because of the conversation between Dr. Clark and myself, and construction of pipelines on both Trans-Mountain and Westcoast and also the Pacific Nothern line from Prince George to Prince Rupert, they have had major problems in construction, in building on talus slopes, and so any pipeline construction man would ask us, would heckle us, "What are you guys going to do about building through the southern route in particular, and across the Richardson Mountains when you come to talus slopes?"

One of the problems, though, is the fact that it's simply a matter of -- it's got nothing whatever to do with permafrost, it's a matter of excavating the stuff. A lot of the rocks may be as big as these tables we have lying around here, and to come in and excavate a trench, to put the pipeline down, becomes a very difficult and costly operation, almost it's invariably cheaper to go off the talus slope. But as Dr. Clark has said here, the talus slope in itself is not necessarily unstable until you cut into it, and then everything starts to move down, and all that he is saying here is that he believes he has a viable solution to locations where he may want to cross a talus slope, and I agree with this. It can be done. He has a mode of doing it.

Then if he has to do it, he'll do it. If there is some better way, if he can get off the talus slope, he'll probably do that, too. But I think it is important at this stage in looking at the feasibility and the design of this pipeline that we can be sure that we have a design plan that will accommodate the variety of,all of the variety of conditions that we anticipate will be encountered. I think perhaps a good deal of the discussion that Dr. Clark has given here this evening could be examined in that context, that he has got modes of construction that will handle all of the eventualities that we can foresee.

THE COMMISSIONER:
Q You may, were you forced to take the interior route, you might have to cut across some talus slopes and then again you might not have to?

A That's right, sir, yes.

WITNESS HARDY: There are going to be some talus slopes that he'll have to cross, I'm sure of that, sir.

THE COMMISSIONER: Well, I think that settles that. You don't want to argue the point, Dr. Clark?

WITNESS CLARK: No sir.

MR. GENEST: You have the last word, Dr. Clark.

A The question is, "Where do we cross it?" We cross them as close to the bottom as possible.

Q And your technique for

dealing with them, if you do have to cross them, you said is to put a stabilizing berm?

A I would say if you like to simplify this, is building up the slope a little bit rather than digging into it, building it up so that we get the necessary protection, the cover required. I think that would be the simplest construction approach.

Q Then, Dr. Clark, I would like to ask you whether, in your opinion, the geotechnical work to date has been of sufficient quality and quantity to enable you to express an opinion as to the feasibility of constructing this line, having regard to the soil conditions, the permafrost conditions and the other relevant geotechnical considerations.

A Yes sir, the geotechnical work completed within our group convinced us that the construction of the line applied for is feasible and that with appropriate design and reasonable construction care and proper revegetation techniques, a chilled natural gas pipeline can be safely operated in northern regions.

Q I'd like to ask the consultants, Dr. Hardy and Dr. Morgenstern, whether they agree with that opinion.

WITNESS HARDY: Yes sir, I agree completely with it.

WITNESS MORGENSTERN: Yes, I do.

MR. GENEST: I would like to move on to the proposed new routing east of Fort Simpson and ask you, Dr. Clark, to discuss the extent of the geotechnical assessment that has been carried out for that proposed new routing.

WITNESS CLARK: The new routing east of Fort Simpson has been terrain typed, and we have referred to previous test borings drilled by the Mackenzie Valley Pipeline Research Limited. A few of these fall actually within our alignment sheet window. We have not done drilling along the line, or at specific sites at this route, on this route but I might add that there are certain sites that I believe this week drilling will be initiated.

It's proposed to do test drilling as necessary for verification of the terrain typing. And at specific areas such as the Mackenzie crossing and the Ebbutt Hills slopes. We have obtained soundings at the proposed crossing of the Mackenzie for a five mile stretch in the vicinity of the crossing. We have developed a preliminary design for this major crossing.

Q Now, the Ebbutt Hills, with which I was not too familiar ten days ago, were brought home to us by Mr. Gibbs in his cross-examination of the previous panel. Have you any comments to make on the geotechnical problems that you might expect to encounter in those hills?

A On the basis of our examination of air photos and the alignments sheets, and a reconnaisence by some of our geotechnical people, we have found no evidence of instability at that particular location. However, it would be classified as, all slopes are classified in our assessment, anything over three degrees, we say that this requires a further look. Certainly this is well over three degrees and will have a substantially more detailed look than a lot of the flatter slopes. We will be doing more work at the Ebbutt Hills, and would not anticipate major surprises but feel that we could deal with them if we did encounter something unusual there.

Q. Sir, Mr. Commissioner, I had in the pre-filed testimony, some questions as to assessment on the Cross Delta Route, I can put them or

not. My intention formed later than the preparation of this material, was to leave Cross Delta, to be dealt with of a piece.

THE COMMISSIONER:

Well, why don't you put that question and let Dr. Clark answer it.

MR. GENEST:

Q Could you describe sir, what geotechnical assessment has been carried out for the proposed Cross Delta Alternate Route?

WITNESS CLARK:

A Yes, sir, the significant water crossings on the Cross Delta Alternative have been sounded in both winter and summer. A test drilling program was carried out prior to breakup in 1974 to determine the nature of the bottom material. At the same time a number of test holes were drilled on the banks and at selected points on the ground. A further drilling program was carried out in the fall of 1974 when a number of borings were put down along the route and on the banks at the crossings now proposed. Preliminary designs have been established for the Shallow Bay Crossing, North Arm Reindeer Channel, Langley Island Channel, which is sometimes referred to as Middle Channel, and the East Channel Crossing.

Q Mr. Commissioner, I am now going to move this panel to the detailed discussion of the Pipeline Application Assessment Group. I hesitate, I know that we have still got about 8 minutes to go, but some of these answers are lengthy, require expositions,

some of them have even got mathametical formulae in them which we thought, while highly technical, we thought it important to get on the record, so that the Commission Counsels and other parties, and scientific advisors, can have the benefit of information. And I wonder if we might break early tonight ,so that I can go at this all of a piece tomorrow morning?

MR. SCOTT: I'm prepared to occupy the eight minutes, not to bail out Mr. Genest, but because there is a matter that frankly concerns me that I think I should raise for his attention, rather than for any ruling, while he is in the midst of his examination in chief.

The preliminary rulings that were made by you in September, provide on page number five, as follows:

" I expect Arctic Gas to call as witnesses the people who prepared the material," and that means the application I gather, " and who carried out the field work on which it is based. I expect Arctic Gas' witnesses to be examined in chief in the usual way, to delineate, explain, and discuss the material filed before cross examination."

Now, Mr. Commissioner, if and when this pipeline is built, I think we will all recognize after the fact, that this panel is perhaps the single most important panel that will appear before you, for the reason that any adverse environmental impact, or indeed many adverse socio-economic impacts that may occur, are going to be met as we heard last week, and

as we've heard tody by particular design features. Now, the test of your ruling it seems to me, would you be able to conclude, following examination and before cross examination in chief, that the design was adequate to the challenges that confronted.

It seems to me frankly and respectfully, and not withstanding the synopsis that while there is some particular analysis given to some problems in that synopsis, and while with respect to the assessment groups report, there is some particular detail given. The bulk of the synopsis, it seems to me has amounted to an assertation, repeated, that there is confidence in the Applicant that they can solve design problems, with occassionally a general statement about the way those design problems may be solved when adequate data or when the data they have is collated.

It seems to me respectfully, that in discharge of their obligation under the rulings, what the Commission is entitled to, is design detail, and the assumptions and data on which they are based, so that the adequacy of these questions can be tested. Now, it may be that that will be coming tomorrow. Certainly from the synopsis of the response to the Assessment Groups Report, it is apparent that there there is some particular detail, and I hope that if this concern attracts Mr. Genest, we will not tomorrow be deprived of that kind of analysis with respect to many of the subjects that have been referred to in the synopsis. I think in essence what I am saying, is that while there has been a full statement of the confidence

of the organization that they can meet these problems, there has not been much particular account, and I emphasize particular, of how, even at this early stage they are going to be met. And in my respectful submission we should have that information in chief, before we are put upon cross examination.

Perhaps Mr. Commissioner, now that I have occupied the eight minutes I can simply leave it there and see what transpires tomorrow, but I did want to emphasize that that matter concerned us.

MR. GENEST:

Well, Sir, if I may make a preliminary response, subject to further comment when I have read Mr. Scott's statement. I would appreciate some guidance from the Commissioner at the end of this panel's evidence in chief. Tomorrow, the evidence that will be led will deal, in what I submit is a detailed way, with the major concerns raised by the pipeline assessment group, who to my knowledge at least were the major outside group reviewing the technical aspects of the engineering of this pipeline.

We have listed in our -- in an appendix to the evidence a very large volume of studies and reports upon which the panel relies and in the preparation of which many members of this panel have been engaged. As far as calling persons who have actually done the work, I have never interpreted your rulings and I may have been wrong, but I have never interpreted them as casting upon Arctic Gas an obligation

to call the man who turned the drill who produced the bore hole from which a record was entered, because this exercise by itself would take three years.

These are the main people who with the main scientific expertise who have been involved in the geotechnical aspects of the engineering of this pipeline. We have listed and we have made available for inspection to all the parties and Commission Counsel the very voluminous technical detailed reports upon which their professional opinions are based.

Now, if it is the desire of the Commission that each one of thse reports should be tabled, should be gone over, should be explained, that to me, in many cases absolutely incomprehensible to a laymen and the technical data contained in them should be read, I, of course, am in your hands, but it seems to me that the purpose of these hearings is to try and explain not only to you, sir, but to the people of the North, what is involved in the engineering aspects and to try and make it comprehensible to them.

It seems to me that if we are going to go into or if I am going to take Mr.SCott's remarks literally, this panel alone could occupy three months of hearing time. Now, perhaps I could ask you to look at these remarks in the light of the information that we have gained at the end of the evidence in chief of this panel. If you are not content, if you find some merits in what Mr. Scott has urged upon you, then, Sir, I would ask for guidance and I expect to be told where we are deficient.

MR. SCOTT: Mr. Commissioner, before we break I may say having known my colleague and friend well, I am used to having what I assume to be a temperate submission reduced to absurdity by him. But I simply say that it seems to me appropriate that this matter should be left to be dealt with at the conclusion of the examination in chief or later. I did feel obliged, however, to bring it -- to bring our concern, for what it is worth, to his attention at this time when he was in the middle of his examination so that if advised he could deal with it.

THE COMMISSIONER: WE will see how we get along tomorrow. We will adjourn until 9 o'-clock tomorrow morning.

(PROCEEDINGS ADJOURNED UNTIL MARCH 18, 1975)